ESTIMATION OF THE PRESENCE AND IMPACT OF FILAMENTOUS AND ODOUR-PRODUCING ALGAE: A SURVEY OF COTTAGERS ON 214 ONTARIO RECREATIONAL LAKES

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EXECUTIVE SUMMARY

A study was conducted in 1985 and 1986, to: (1) determine if analysis of a survey of cottagers' perceptions could allow accurate identification of lakes with two types of algae: filamentous and odour-producing algae (hereafter **odour algae**); (2) to estimate incidence of the two types of algae in central Ontario recreational lakes; and (3) to explore impact of these algae on cottagers' recreational enjoyment.

Need for the study was outlined by the Ministry in the initial Terms of Reference for the study:

> ... Of particular concern is the growth of two types of lake algae, both of which may interfere with human use and enjoyment of such lakes. Mass development of filamentous algae can clog shorelines and affect recreational uses, while a specific type of planktonic algae produces a distinct, unpleasant odour.
>
> Recent evidence suggests that the growth of these algal species has been increasing in recent years in softwater lakes, possibly as a result of increasing acidification. While detailed field and laboratory studies are currently under way to determine the causes of algal growth, little information exists on the extent of such growth in softwater lakes in central Ontario or its impact on human uses...

The study involved a pilot study of some 200 cottagers in 1985, and a major survey of over 5,200 cottagers in 1986.

The Pilot Survey

Questionnaires were collected from cottagers on ten lakes in central Ontario in Summer, 1985, in a pilot study of these issues. The pilot study of ten lakes included three lakes known to the Ministry of the Environment as having odour algae, and six lakes known to the Ministry as having varying amounts of filamentous algae. Four lakes were known to have neither.

Results of the pilot study demonstrated: (1) that predictions of the presence of both types of algae could be improved beyond chance by using a survey of cottagers' perceptions (and certain statistical predictive models, as discussed below); and (2) that certain negative impacts were attributed to algae by the cottagers. Success of the pilot survey led to a larger scale survey in 1986, of over 5,200 cottagers on 204 lakes.

The Main Survey

The main survey was conducted for a random sample of some 178 lakes with populations of ten or more cottagers. It was also conducted for an additional sample of 26 lakes for which there was evidence of filamentous or odour algae. In total, over 5,200 cottagers were surveyed.

Overall, the survey of cottagers achieved a high response rate. Over 80% of cottagers completed the survey and mailed it to the survey office. The high survey response rate reflected considerable interest by cottagers, and apparently the view of many, that these types of algae and lake phenomena generally were important to cottagers.

Predicting the Presence of Filamentous and Odour-Producing Algae in the Main Study

The test of validity of the survey method centred on development and testing of a number of quantitative predictive models, based on the statistical technique known as discriminant analysis. Validity of each model was assessed in terms of ability to accurately predict (percentage of lakes correctly classified) the algae status of a sample of lakes previously studied by the Ministry of the Environment.

The analysis of the main survey data was extended to test predictive models developed in the pilot study, using "cottager" level data, and also new predictive models based on aggregated data (average scores for the survey variables) for each lake. Main study predictive tests were based on 32 known status lakes for filamentous algae, and 10 known status lakes for odour algae.

The newly developed aggregate-level models were found to be more reliable than the "cottager level" models that had been developed in the pilot study. The explanation of improved predictions at the aggregate level was that the averaged data provided a clearer view of the "consensus" of cottagers, and also clearer rules for classifying predictive results.

Using the final predictive models, 97% of filamentous lakes with known algae status could be correctly classified; 100% of odour algae lakes with known status could be correctly classified. These predictions were regarded as extremely good, although possibly overstating the reliability of estimates. Since the results were based only on a small sample of lakes, it was noted that true reliability of the predictive models would probably be somewhat less than the 97% and 100% indicated.

Incidence of Algae on Lakes

The survey estimates indicated that some or considerable filamentous algae could be found on 47.7% of all lakes in the population of lakes surveyed. Of these lakes, 31.6% were estimated to have some filamentous algae, and 16.1% were estimated to have

considerable filamentous algae. Incidence of filamentous algae appeared to be greatest in the Muskoka District where a majority of populated lakes (54.2%) were estimated to have filamentous algae.

Survey estimates indicated far less presence of odour algae: some 6.1% of populated lakes were estimated to have odour algae. These were also more likely to be in Muskoka, where 12% of all lakes were estimated to have odour algae.

Relation to Acid Conditions

The presence of both filamentous and odour algae appeared to be correlated with lake acid sensitivity, with more sensitive lakes being more likely to have both types of algae.

Impacts of Algae

Substantial numbers of cottagers reported negative impacts of both types of algae. These impacts included: general reduction in lake enjoyment, and specific effects such as reduced enjoyment of swimming and boating.

For example, 74% of cottagers reporting filamentous algae identified reduced aesthetic enjoyment as a problem, and 68% reported reduced swimming activity. Similar impacts were found among those reporting odour algae: 71% reported reduced enjoyment of swimming activity; and 64% reported reduced aesthetic enjoyment.

Seriousness of these algae-related concerns was reflected in cottagers' overall evaluation of lake problems. Among cottagers reporting the presence of algae, presence of filamentous and odour algae were ranked as major problems, along with effects of acid rain, and poor or declining quality of lake water generally.

Future Research

Further research is recommended, to verify certain of these findings, particularly the extension of this work to include a more comprehensive population of lakes, using additional water chemistry data (and acid sensitivity in particular). Further refinement of predictive models (especially using water chemistry data) and clarification of impacts is also recommended.

Chapter 1. Introduction

1.1 BACKGROUND AND STUDY OBJECTIVES

1.1.1 Objectives and Rationale

This report describes a survey for a study of algae in softwater lakes in central Ontario. The overall objectives of the study as stated in the initial Terms of Reference, were:

1. To obtain accurate estimates of the incidence of two types of algae growth* in soft water lakes in central Ontario; and

2. To identify the extent to which such algae growth is perceived by lakefront property owners to be a problem which may affect their use of the lake or their property.

As Ministry concerns were outlined in the terms of reference:

> ... Of particular concern is the growth of two types of lake algae, both of which may interfere with human use and enjoyment of such lakes. Mass development of filamentous algae can clog shorelines and affect recreational uses, while a specific type of planktonic algae produces a distinct, unpleasant odour.
>
> Recent evidence suggests that the growth of these algal species has been increasing in recent years in softwater lakes, possibly as a result of increasing acidification. While detailed field and laboratory studies are currently under way to determine the causes of algal growth, little information exists on the extent of such growth in softwater lakes in central Ontario or its impact on human uses...

The basic rationale for the study emphasis on a survey of cottagers was that the use of cottager perceptions was seen as a more cost-efficient means of identifying algal conditions of lakes than could be achieved using traditional field assessment techniques. Traditional field assessment techniques, it was argued, would be prohibitively expensive, given the large number of lakes to be tested.

The policy rationale for the overall study was that the growth of these types of algae in Ontario lakes is a matter of importance because of: (1) potential recreational and tourism impacts; and (2) possible environmental considerations with respect to expansion of algal growth as a result of lake acidification.

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*Cloud-forming filamentous algae (e.g. Zygnema); and odour-producing algae (Chrysochromulina breviturrita). Hereafter these are referred to as: "filamentous" and "odour" algae, respectively.

1.2 ASSUMPTIONS/HYPOTHESES

The survey concept was founded on two main premises:

1. That cottagers may be able to describe lake phenomena accurately (e.g. growths in the water, odours or other lake characteristics related to algae growth).

2. That the **consensus** of views of a **number** of cottagers on a given lake may provide accurate assessments of lake phenomena.

The survey was designed and conducted in a multi-disciplinary scientific environment, drawing on the one hand from biological models of the algae and their manifestations, and drawing on the other, from a more formative psychological view of how perceptions and attitudes of people might vary in relation to various kinds of substances (algae, scum, weeds, etc.) in their lake.

The test of validity of the survey method centred on development and testing of a number of quantitative predictive models based on the statistical technique called discriminant analysis. Validity of each model was assessed in terms of ability to accurately predict (percentage of lakes correctly classified) the algae status of a sample of lakes previously studied by the Ministry of the Environment (a detailed discussion of discriminant analysis is provided in Section 2.2 below).

Two types of predictive models were considered in the pilot study analysis:

1. Various **core models** based on direct reports of "seeing" or "smelling" algae, or reports of related observable lake phenomena.

2. **Test models** which added new variables (derived through an exploration of the data set) to the core observational models, most importantly, a "lake misperception" variable.

The pilot study results, which are recapitulated below, illustrate that these different approaches are complementary.

1.3 THE PILOT STUDY

The pilot study was conducted mainly to test the practicality and predictive power of the survey method (and also to provide an initial view of impacts of algae). Below, we provide a review of the main points of the pilot study methodology, key findings, etc. (the reader should review the pilot study report for full details).

1.3.1 Method

The pilot study involved a detailed survey of cottagers on ten lakes known by the Ministry of the Environment to have or not have filamentous or odour algae (six of the ten had varying degrees of filamentous algae, and three of these also had odour algae).

A survey of cottagers was conducted by "drop-off" at the cottages, with mail return to the study office. Survey responses were obtained from 75% of respondents who answered questions about their certainty that they had seen (or smelled) the types of algae described. Chapter 2 of this report provides an overview of the basic questionnaire, which was unchanged in significant respects from the pilot to the main study (see pages 8 to 9, below).

1.3.2 Predictions Regarding the Presence of Algae

Predictions of algae status were made using discriminant analysis of "cottager level" survey responses, as is outlined in Display 1.1. (Discriminant analysis is described in Section 2.2.) As can be seen in Display 1.1 below, this involved several key steps.

DISPLAY 1.1
STEPS IN PREDICTING LAKE STATUS FROM COTTAGER LEVEL DATA
(individual survey responses of cottagers)

STEP 1: One or more predictive variables are entered into a discriminant analysis to predict actual lake status as determined previously by the Ministry of the Environment.

STEP 2: From the discriminant analysis equations, and the cottagers' responses to the questions used as predictive variables, a predicted lake status is estimated for <u>each</u> cottager.

STEP 3: <u>For each lake</u>, predicted algae status is determined by examining the individual cottager predictions. Where most cottagers (or a plurality) are predicted as "NIL's," the lake is classified as a "NIL" algae lake. Where most cottagers indicate "SOME," the lake is classified as a "SOME" algae lake, and so on.*

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*"Nil," "Some," and "Considerable" were qualitative ratings in the pilot study, but emerged as quantitative classifications in the main study.

These results were generally satisfactory for filamentous algae, indicating (with different predictive models used) that 64% to 69% of cottagers could be classified as to the algae status of their lake, on the basis of their survey responses; but that **taking the survey responses of all cottagers on each lake, 70% to 100% of lakes could be correctly classified as to algae status.** Highest percentage of correct classifications was obtained where "lake misperception"* was added to descriptive reports on presence of filamentous algae.

Results for odour algae were similar although somewhat less accurate overall: 69% to 86% of cottagers could be correctly classified as to odour algae status of their lakes, and 70% to 90% of lakes could be correctly classified as to odour algae status. As with filamentous algae, highest percentage of correct classification was obtained when "lake misperception" was added to descriptive reports on presence of filamentous algae.

Overall, we concluded that reasonably accurate predictions could be made using the cottager survey data.

1.3.3 Indications of Impact

The pilot survey also suggested that substantial impacts might occur, in the form of filamentous algae and odour algae reducing enjoyment of lakes.

Cottagers reported impacts such as: general reduction in enjoyment; reduced swimming; reduced aesthetic enjoyment; worries about health; impact on drinking water; and similar issues.

1.3.4 Decision to Undertake a Larger Study

On the basis of these results, a larger survey was planned to further apply the predictive modelling approach, and to answer further questions on incidence and impacts.

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*Lake misperception was a variable created to measure the tendency of cottagers to "overreport" noxious or smelly phenomena. In the final analysis, lake misperception was measured by a factor score (see Section 2.2) for a single factor indicating propensity to notice weeds, green scum, algae, smells, etc.

1.4 PLAN OF THE REPORT

The report includes the following main chapters:

Chapter 2: Methodology, describes how the study was designed, including: the survey methodology, selection of test lakes, design of questionnaires, quality of data obtained, and statistical techniques used.

Chapter 3: Predicting the Presence of Filamentous Algae in Recreational Lakes, describes the initial and final models developed for predicting the presence of filamentous algae.

Chapter 4: Predicting the Presence of Odour Algae in Recreational Lakes, describes the initial and final models developed for predicting the presence of odour algae.

Chapter 5: Incidence of Algae and Acid Sensitivity of Lakes, examines the estimated incidence of algae in central Ontario recreational lakes, the relation of actual and predicted algae status to acid conditions of lakes.

Chapter 6: Estimating the Impacts of Algae, provides a brief overview of recreational and other impacts of algae, as evidenced by the reports of cottagers.

Chapter 7: Summary and Conclusion, reviews the main study results.

Chapter 2. Methodology

2.1 OVERVIEW

Our outline of the methodology includes discussion of the final study questionnaire, sampling of the study lakes where the final survey questionnaire was distributed, response rates, etc., weighting of data for incidence estimates; statistical techniques and other issues.

2.1.1 The Survey Method

The survey design used in the study is outlined below in several sections describing: (1) the general approach; (2) the questions asked; (3) the questionnaire and survey process; and (4) sampling.

(1) Overview of Survey

The objectives of the survey were to estimate the incidence of the two types of algae in Central Ontario recreational lakes, and to explore the impact of these algae on cottagers' recreational enjoyment.

The method involved collection of survey data from a random sample of cottagers from the cottage population of a random sample of lakes. These cottagers responded to a mail-out questionnaire regarding presence of algae in their lake and the possible effects of algae on lake use.

The rationale for selecting a mail questionnaire was primarily logistical. Field interviews with cottagers were seen as prohibitively expensive. It was concluded that a mailed survey could be designed to incorporate visual material (pictures if desired, etc.), and that the relative economy of the mail-survey would allow for a larger overall sample size. A good sample size was seen as essential to obtain a reliable reading of "consensus" among cottagers.

Perceived presence or absence of algae was measured by means of "attitude" type questions designed to assess cottagers' perceptions of algae and related lake phenomena.

(2) Types of Questions Asked

A variety of questions were used, as noted below (Appendix A shows the actual questionnaire).

Core Question: Filamentous Algae: The "core" questions of the questionnaire related to: (1) descriptions of the algae; and (2) the perceived presence or absence of each type of algae.

For example, the core question regarding filamentous algae was introduced by a picture and verbal description of filamentous algae, "*Many lakes have a type of algae which is called FILAMENTOUS ALGAE which usually look something like the picture below. It is often described as "clouds of algae", "cotton candy clouds*". The question was: *"Have you or your family ever noticed filamentous algae in your lake?"* The core question was followed by additional descriptive information and a colour picture of a portion of a lake with filamentous algae. The description was followed by a five-point rating scale, on which the lake user indicated whether that type of algae had ever been noticed by them on the lake. (See page 2, and Question 5, Appendix A, for the actual description and question.)

Core Question: Odour Algae: The verbal description for odour algae was: *"Some lakes have a type of microscopic algae (which we will call "ODOUR ALGAE" for short). These algae cannot be seen by the naked eye but have a very distinct odour, similar to that of cooking cabbage or a very 'ripe' compost heap."*

The question for odour algae took the same general form as the question for filamentous algae, asking "Have you/your family had ever noticed this type of odour in your lake?" (see page 4 and Question 15, Appendix A).

Supplementary Questions on Filamentous Algae and Odour Algae: Other questions were asked about the two types of algae to provide more in-depth measurement. These included: whether algae were noticed in each of: 1985, 1984, 1983, 1982, 1981, 1980 or earlier, and whether algae were noticed in each of May, June, July or August, 1985. In addition, selected questions were asked about distribution and frequency of algae, whether algae were a matter of concern, and about perceived change in past 5 years.

This variety of questions was included to allow for possible development of multi-item indicators and prediction models. (See Appendix A, Questions 6 to 14, for specific questions regarding filamentous algae, and Questions 16 to 20 for the related questions regarding odour algae.)

Supplementary Questions on Related Phenomenon: A variety of supplementary questions were included regarding additional lake phenomena, to test cottagers' ability to accurately identify these other conditions, and also to clarify the overall perceptual context for cottagers' reports of algae being present. These included perceptions of such phenomena as: brown water, yellow scum on lake water, green scum on lake water, odour in water filters, weeds and vegetation growth, fishy odour, and musty odour, etc. (see Appendix A, Questions 21 and 22); and questions regarding problems on lakes, such as declining fish populations, declining quality of lake water, acid rain, too much recreational activity (Questions 3 and 23).

The most important purpose of these questions was to determine if supplementary predictors or valuable "control" variables could be constructed from related perceptions. A particular concern was to see whether perceptions of some individuals might be affected by a tendency to be generally (or overly) sensitive to all kinds of noxious phenomena, or to systematically overreport various types of "guck" or smell. (The "lake misperception" variable discussed above.)

Impact Questions: Two questions were also asked regarding impact of filamentous algae (see Appendix A, Question 14) and odour algae (see Appendix A, Question 20). Both of these questions took the form: *"Do you believe the presence of this algae has: (a) reduced overall enjoyment of the lake by yourself for your family?; (b) reduced fish population?"* and so on.

Aspects of impact examined included enjoyment of swimming and boating, health, aesthetic enjoyment of the lake. For each question cottagers could check a box indicating enjoyment was "not affected at all" or, alternately, a specific degree of reduction of enjoyment.

Demographic and Control Questions: To provide a demographic profile of cottagers and potential "control" variables, several questions were included to describe cottagers, amount of use of the lake, recreational activity, and related variables. These included, for example: number of years on lake, portion of year using the cottage, and self-assessment of overall familiarity with lake conditions.

(3) Sampling

Sampling Lakes

The population of lakes studied was drawn primarily from populated lakes in Central Ontario (see Display 2.2), an area known to contain a high proportion of lakes sensitive to acid precipitation. This population (estimated to include some 330 Ontario recreational lakes) was sampled in the following manner.

The population of lakes was stratified on two key variables of concern to the Ministry: (1) acid sensitivity of lakes; and (2) completeness of available water chemistry data.

Rationale for the first stratification variable was that acid sensitivity was important because of the hypothesized relation of acid sensitivity to algae conditions (because of the small number of lakes in the low and high sensitivity categories these lakes were to be oversampled to provide sufficient numbers for later analysis). The rationale for the second stratification variable was that subsequent analysis of the survey data might involve inclusion of additional water-chemistry data available in Ministry of Environment and Ministry of Natural Resources information systems. Since this information was not available for all lakes, it was decided that the survey of cottagers should over-sample lakes with complete water chemistry data.

To do this, and at the same time maintain representativeness of all lakes with ten or more cottages, the lakes were sampled from a stratification scheme suggested by Display 2.1. Lakes in the first two rows and last row, and in column one of the display, are oversampled (lakes are chosen randomly, but more lakes are sampled than would be expected proportionately). This initial oversampling is compensated for in later analysis by introduction of weights which offset the differential sampling fractions used in selection of the initial sample. (For example, if a sub-strata of lakes were sampled 100%, they would receive a weight of 1.0. If a sub-stratum were sampled only 50% in the initial sample, the lakes included would receive a weight of 2.0 in the final analysis. All weights combined reflect the best estimate of the actual lake population.) Accordingly, the results presented in Chapter 5 of this report have been weighted to represent the population of all Ontario recreational lakes known to have ten or more cottages.

Lakes were randomly sampled as noted in Display 2.1.

DISPLAY 2.1

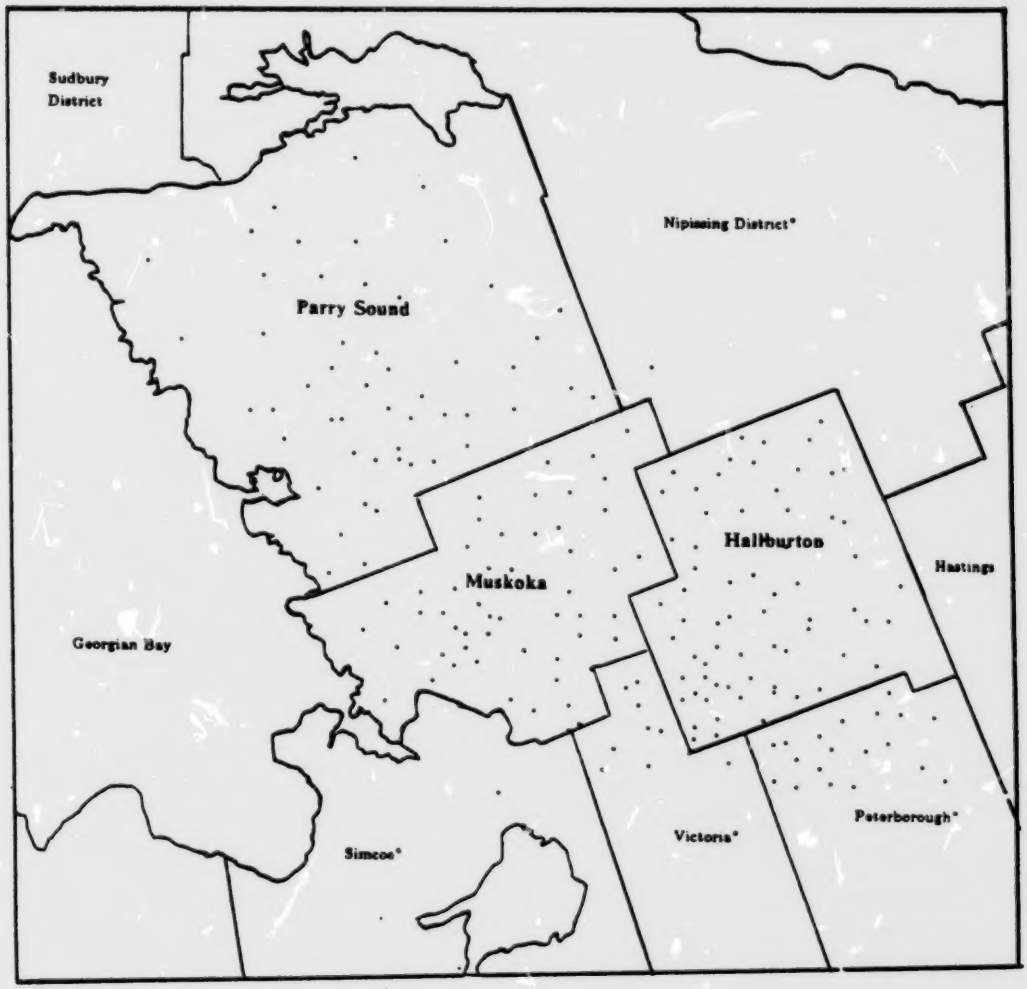
LAKES SAMPLED BY STRATA
(this table shows the allocation of the final random sample across two stratification dimensions: acid sensitivity level; and completeness of available water chemistry data)

Acid Sensitivity*	Completeness of Available Water Chemistry Data: Maximum	Moderate	Minimum	Total
1	1	0	1	2
2	16	12	9	37
3	32	17	28	77
4	16	9	5	30
5	16	3	13	22
	81	41	56	178

*Measured as alkalinity over a range of <0 micro-equivalents per litre to >500 micro-equivalents per litre (1 = less than 0; 2 = 0 - 40; 3 = 40 - 200; 4 = 200 - 500; and 5 = over 500).

DISPLAY 2.2

GENERAL DISTRIBUTION OF LAKES SAMPLED BY COUNTY AND DISTRICT
(Each dot shows very approximate location of a sampled lake)



Sampling Cottagers

The sampling frame for selection of cottagers was the Ontario Assessment System. This system provides a physical description of every property in Ontario, and names and addresses of owners. It is the system used for levy of property taxes.

The Assessment System was accessed for this survey in the following way. Individual lakes, once sampled on the basis discussed above, were located in the Ontario Assessment system, and regional offices of the Ministry of Revenue approached, to locate maps showing the properties on each lake. For each lake all properties were identified as to the 18 digit assessment roll number for each property (or, on larger lakes, a sample of properties was taken). These numbers were then processed through the Ministry of Revenue computer information system, to identify the properties with cottages, and to list names and addresses of owners.

For each lake, a target number of cottages was determined to represent the lake. On large lakes, the sample size was set at about 40 cottagers. On small lakes, all cottagers were included in the sample, with varying numbers of cottagers selected for lakes of in-between size.

Selection of cottagers was systematic relative to assessment lists of lake properties: on each lake, approximately "every third", "every fourth" cottage, etc., as determined by the researchers, was selected to achieve the target number of cottages.

(4) Survey Method and Process

Distribution of Questionnaires and Reminders: Initial questionnaires were distributed by first-class mail in June 1986, with an explanatory letter from the Ministry of the Environment and a pre-paid postage return envelope. Follow-up took the form of reminder mailings: (1) a postcard reminder; (2) an additional letter and questionnaire; and (3) in selected cases, telephone reminder calls. Of the over 5,200 cottagers sampled, 79.2% returned completed questionnaires by the close of the survey in September 1986. Additional returns received after September, raised the response rate to over 80%.

Reliability of Resulting Data

Prior to analysis of predictive models, the survey data were examined to see if responses were generally systematic, logical and reliable. This was done with particular emphasis on assessing structure of the data, and assessment of reliability in general.

By structure, is meant the tendency of related questions to be answered logically and consistently, and to reflect behavioural patterns. For example, a series of questions asking cottagers if they were "concerned," "worried," or "upset" about filamentous algae would be expected to generate relatively consistent answers, since they measure different reactions to the same phenomenon. The answers therefore would be inter-correlated. Structure was tested using factor analysis (mainly in the pilot study data). Factor analysis is a multivariate statistical technique which is commonly used to identify patterns underlying perceptual (and other) data, by examining correlations between variables.

Factor analysis of the pilot study data suggested good patterning of data generally, and good reliability of data, as indicated in four areas.

Factor analysis of filamentous algae recognition questions in the pilot study illustrated three major factors, relating mainly to: (1) awareness of filamentous algae; (2) perceptions of other noxious lake characteristics; and (3) concern over filamentous algae and its impact (see Appendix B, Pilot Study Report, for key factor results).

Factor analysis of odour algae recognition questions illustrated similar regularity of response patterns. The main factor for odour algae variables also related to awareness; while a second and third factor related to perceptions of other noxious lake phenomena; and overall level of smell. A factor analysis of odour perception questions also produced three distinct factors (see Appendix B, Pilot Study Report).

Factor analysis was also carried out on the pilot study recreational activity questions (see Appendix A, Pilot Study Report, Question 4 and Question 5). This analysis identified four common recreational activity and enjoyment patterns on the pilot study lakes. These factors showed strong structural integrity of data, and good structure overall. (See Appendix B, Pilot Study Report, for detailed factor result.)

As well, a unidimensional indicator of lake mis-perceptions was developed using factor analysis. This is discussed in Section 4 of the Pilot Study Report.

Reliability of indicators was also considered. By reliability is usually meant: the capability of an indicator to provide the same result each time it is used (e.g. as a ruler will regularly measure a pencil to be of a certain length, if the pencil is not altered). In attitude research, indicators are not generally as reliable as rulers, but their reliability can be assessed using certain statistical tests. Our approach was to estimate Cronbach's ALPHA, as a measure of reliability for indicators. (It is expected to fall between ALPHA = .7 and .9 for indicators of reasonable reliability.)

These results suggested very good reliability overall. For example, estimates of Cronbach's ALPHA for the four pilot study recreation factors ranged from .77 to .88, and ALPHA's in the same range for other factor indicators. Similar indications of reliabiity were noted for the data collected in the main survey.

Overall, the study data showed good evidence of careful completion by respondents, and good structure and reliability. These results suggested that the analysis could proceed with good confidence in the overall reliability of the survey data.

2.2 TYPES OF STATISTICAL TECHNIQUES USED

The reader should note that extensive use is made of the concepts of correlation and statistical significance, which are briefly explained here. When we say that two factors (e.g. housing and health) are correlated, we usually mean that they "go together", and this implies that a change in one will result in a change in the other. For example, in studies of social welfare, it is often argued that because the factors are correlated, an improvement in sub-standard housing will generally result in an improvement in health. Correlations may therefore convey social and political truths, or raise social and political issues.

The type of correlation coefficient reported here is **Pearson's r**, which ranges from -1.0 (perfect negative relationship) to +1.0, perfect positive relationship. A correlation of .0 indicates no relationship. Pearson's r is generally regarded as an appropriate statistic for data which is measured in a quantitative manner. Where the number of categories is few however, it may understate the correlation somewhat.

Statistical Significance is assessed for correlations and other statistical tests, to determine whether the results are scientifically reliable within certain limits. In this report, a correlation is generally considered to be "significant" at a probability level (P) of .01 or less. This means that the relationship (or correlation) is unlikely to be a "chance" occurrence, and would be expected to occur 99 times out of 100 if the study method was repeated.

Factor analysis is an analytic technique used extensively in the human sciences, to identify the dimensional regularities of a complex field of data. It relies on multi-variate analysis to identify one or more underlying factors which explain a large number of variables. (A factor score is the measure of where a respondent "scores" on a particular factor.)

To illustrate a typical use of factor analysis: in the pilot stage of this study, many different types of recreational behaviour were examined, including different types of boating, swimming, passive enjoyment of the lake, and different aspects of recreation such as frequency of activity and enjoyment. Through factor analysis, a few key factors or sets of variables were identified to summarize recreational enjoyment. With a more simplified set of key "factors", more reliable indicators can be created (multi-variable indicators are generally more reliable in quantitative analyses), and policy inferences drawn with greater precision. In this study, factor analysis has been used only to test reliability of questions, which are deemed more reliable if consistent factors can be extracted.

Multiple regression is a statistical technique which attempts to explain a given phenomenon by looking at its correlation with a number of characteristics simultaneously. This is as opposed to simple cross-tabulations (tables) which allow only one or two variables to be considered at a time, or simple correlations between pairs of variables. To over-simplify, including any variable (call it "X") in a multiple regression procedure asks the following question: holding other things constant, is variation in X associated in some way with changes in the particular outcome measure being predicted.

Multiple regression tells us how important any such association is, and whether that association is statistically significant (even in relatively large samples, some correlation may occur by chance: statistical analysis lets us isolate those relationships that are very likely not due to chance. We report results where the odds of being a chance finding are less than one in twenty ($P \leq .05$), with special attention being given to results that are due to chance with odds of less than one in a hundred, $P \leq .01$).

Discriminant analysis is a multi-variate statistical technique commonly used to classify individuals or other units of analysis (such as lakes) into mutually exclusive groups such as "has odour algae" versus "does not have odour algae". This is done using a predictive model somewhat related to multiple regression. Technically, the technique involves estimation of an optimal linear discriminant function,* and then a prediction of group status for each unit in the analysis.

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*See: *Advanced Statistics: SPSS/PC+*, SPSS Inc., Chicago, 1985.

Chapter 3. Predicting the Presence of Filamentous Algae in Recreational Lakes

A major concern as the analysis of the main survey began was centred on the question as to whether the method demonstrated in the pilot study would "work" in accurately predicting filamentous algae status on a larger sample of lakes and cottagers.

Several factors were considered which might have resulted in a successful pilot, but one which could not be repeated. Among these, main concerns were: the unique "cultures" of the 10 lake sample, including certain encounters between cottagers and the provincial government regarding "doing something about algae," and the possibility of the lakes representing more extreme cases, and thus being more easily predictable than would be the case for a random sample of lakes.

As well, of course, the small sample used in the pilot study posed risks for replicability of the predictive models. With only ten lakes to calibrate the predictive models, a model might "fit" the sampled ten lakes well, simply as a "chance" occurrence. This seemed unlikely, given the appearance in the models of logically appropriate predictors, but degree of reliability was a matter of concern.

Accordingly, a first step in the study (for filamentous algae at least) was to "re-calibrate" the predictive models, using a larger sample of known status lakes. For this purpose, the Ministry of the Environment provided additional data on "known filamentous algae" status, for 32 lakes in the survey.

The predictive models discussed below (replications from the pilot study, along with new models) were all tested on this population of 32 lakes.

3.1 INITIAL PREDICTIVE MODELS USING COTTAGER LEVEL DATA

The initial model tested examined accuracy of predictions made with "cottager level" data (averages) for the core "perception of algae" question. This analysis was done for the 32 lakes with known algae status which were in the main study. The results for this analysis were generally not as good as the same model demonstrated in the pilot study. Only 56% of cottagers were correctly classified, and overall, 70% of all lakes were correctly predicted (based on a plurality in the correct category for a given lake).

Predictions were especially poor for the lakes with "some" algae, according to the Ministry. Cottagers' responses to the core questions were reasonably useful for classifying lakes with "nil" algae* (83%), or "considerable" algae (91% correct), but cottagers' responses to the core question misclassified all of the "some algae" lakes.

---

*Used throughout the main study: "nil" or minimal = less than 5% of shoreline with filamentous algae; "some" = 5 to 20% of shoreline affected; "considerable" = over 20% of shoreline affected.

3.2 PREDICTING THE PRESENCE OF FILAMENTOUS ALGAE FROM A MULTIVARIATE MODEL (Cottager Level Data)

3.2.1 Relevant Predictor Variables

The second model tested was a multi-variate (step-wise discriminant) analysis, into which a number of algae-related questions (and others) could enter.

As can be seen in Display 3.1, a number of variables entered the multi-variate model, most of which replicated the variables which emerged in the pilot study analyses. These included the question regarding noticing algae in August 1985, correct identification of the filamentous algae colour as gray-green, the misperception variable, presence in all parts of the lake, and concern about filamentous algae. Some new variables entered, most importantly, Question 12 asked respondents if they or family members had "ever picked up the filamentous algae" (Ministry biologists were of the view that this question would distinguish filamentous algae from similar algae which could not be picked up physically).

DISPLAY 3.1

PREDICTIVE VARIABLES* FOR A DISCRIMINANT ANALYSIS MODEL
TO PREDICT PRESENCE OF FILAMENTOUS ALGAE USING COTTAGER LEVEL DATA

VARIABLE/ SURVEY QUESTION	DESCRIPTION OF VARIABLE
Q9AUG	NOTICED FILAMENTOUS ALGAE IN AUGUST, 1985
Q7	COLOUR IS GRAY GREEN
MISPER	MISPERCEPTION VARIABLE
Q11COL1	FILAMENTOUS ALGAE IN ALL PARTS OF THE LAKE
Q12	PICKED IT UP
Q25	FAMILIARITY WITH LAKE (SELF RATING)
Q21G	NOTICED GREEN SCUM ON ROCKS
Q14A	FILAMENTOUS ALGAE REDUCED ENJOYMENT
Q13	CONCERN ABOUT FILAMENTOUS ALGAE

*Shows variables in order entered in step-wise discriminant analysis. Best (most powerful) predictors enter first.

3.2.2 The Multivariate Result

With the multivariate model, a slight improvement was obtained in cottager and overall lake predictions. Overall, 61% of cottagers were correctly classified, and 75% of all lakes correctly classified by the plurality rule (a plurality of cottagers are classified in a manner which matches "known status" as determined by the Ministry).

Only in the area of classifying lakes with some or considerable algae was the increase in predictive power noticed: 2 of 6 "some algae" lakes were correctly predicted by the multi-variate model, as compared to none accurately predicted using the single question model.

These results were significant well-beyond chance, but generally less accurate than the results obtained in the pilot study, where the multivariate model correctly predicted the filamentous algae status of all ten pilot study lakes.

3.3 EXTENSION OF PREDICTIONS TO AN AGGREGATE DATA MODEL (Average Lake Scores)

Because of the desire to produce lake-level classifications ultimately, and because of the reduced accuracy of predictions noted above (as compared to the pilot study) the researchers explored -- an alternative approach to predictive modelling -- aggregate level predictive models. This step was also taken on the grounds of our initial assumption, that the "consensus" of a larger number of cottagers -- their views taken together, would provide a better estimate of algae presence than would a single cottager alone.

These models involved the generation of average scores for the survey variables, for each lake. (See Appendix B for a detailed discussion.) Aggregation was completed as noted below in Display 3.2.

DISPLAY 3.2

STEPS IN AGGREGATION TO AVERAGE LAKE SCORES

STEP 1: Cases for each lake are grouped together.

STEP 2: Averages for each variable are computed for each lake (all cottagers for that lake combined).

STEP 3: New aggregate level cases are generated, with each lake constituting one "case", e.g. for a given lake, cottagers reports are combined, by averaging, to produce average scores on each variable for that lake. (See Appendix B.1 for details.)

STEP 4: One or more predictive variables are entered into a discriminant analysis to predict actual lake status (as determined previously by the Ministry of the Environment).

STEP 5: From the discriminant analysis equations, and averages of cottagers' responses to the questions used as predictive variables, a predicted lake status is estimated for each lake.

3.3.1 A Single Score, One Variable Model to Predict Filamentous Algae (Average Lake Scores for Question 5)

Aggregated data was provided as discussed above, by averaging responses for all cottagers on each lake, so that a single lake score was produced (the numeric mean) or average for each lake variable. These were then introduced to a discriminant analysis model where we attempted to predict algae status for the lake from one variable only, the average for each lake, of all of that lake's cottagers' responses to the core filamentous algae perception question (Question 5).

The overall results from this model were relatively good (75% of lakes accurately predicted overall), comparable to the accuracy obtained with the multivariate model using cottager level data, and better than the cottager level result for Question 5, which was 70%.

Greatest improvements were in the predictions for "some algae" lakes, where 4 of 6 (or 66%) were correctly predicted, but a slight loss in predictive power was observed for the "considerable" lakes. Overall, however, the result was far superior to the non-aggregated single question model noted earlier in Section 3.2.1, so that that we speculated still greater improvements in predictions would be obtained from a model combining the power of a multi-variate model with the improved power obtained at the aggregated level of data.

As is seen in the section to follow, this hypothesis was proven correct.

3.3.2 A Final Aggregate/Multi-Variate Model For Filamentous Algae

The final model tested was based on aggregate data, and allowed multiple variables to enter the prediction equation. The variables included in the analysis were limited to a sub-set of variables which had been previously identified as having biological or psychological validity. These are noted in Display 3.3 (next page) in the order in which they entered the prediction equation (variables which enter first have highest predictive power).

This model correctly predicted algae status of 97% of lakes (31 of 32 lakes), and correctly predicted 100% of lakes with "some" or "considerable" algae. Overall results are shown below in Display 3.4, which summarizes the results of all four models.

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*It should be noted that the list of predictor variables differs for the cottager level data (Display 3.1), and the aggregate level data (Display 3.3). The reason for this may be the effect of averaging in the aggregate model, in displacing variables such as the lake misperception variable, and the self-rating of awareness, which were significant predictors at the cottager level, but not at the aggregate level of analysis.

DISPLAY 3.3

PREDICTIVE VARIABLES* FOR A DISCRIMINANT ANALYSIS MODEL
TO PREDICT PRESENCE OF FILAMENTOUS ALGAE USING AGGREGATED DATA

VARIABLE/ SURVEY QUESTION	DESCRIPTION OF VARIABLE
Q21f	NOTICED CLOUDS OF ALGAE FREQUENTLY
Q21d	DID NOT NOTICE GREEN SCUM ON WATER
Q6	IDENTIFIED COLOUR OF FILAMENTOUS ALGAE AS GRAY-GREEN
Q23c	POOR OR DECLINING APPEARANCE OF LAKE AND SHORELINE A PROBLEM
Q23e	FILAMENTOUS ALGAE IDENTIFIED AS A PROBLEM
Q6	DID NOT IDENTIFY COLOUR OF FILAMENTOUS ALGAE AS DARK GREEN
Q12	HAD PICKED UP FILAMENTOUS ALGAE
Q8	NOTICED FILAMENTOUS ALGAE IN 1985
Q5	EVER NOTICED FILAMENTOUS ALGAE
Q11COL1	NOTICED FILAMENTOUS ALGAE IN ALL PARTS OF LAKE
Q9AUG	NOTICED FILAMENTOUS ALGAE IN AUGUST 1985
Q7	IDENTIFIED PALE GREEN AS MOST TYPICAL COLOUR

*Shows variables in order entered in step-wise discriminant analysis. Best (most powerful) predictors enter first.

DISPLAY 3.4

PREDICTING THE PRESENCE OF FILAMENTOUS ALGAE FROM
VARIOUS PREDICTIVE MODELS: PERCENTAGE ACCURACY

	Cottager Level Models		Aggregate Level Models	
	Core Question*	Multivariate**	Core Question***	Multivariate****
Known Status+				
Nil	83%	80%	83%	93%
Some	0	33	66	100
Considerable	91	91	86	100
TOTAL % ACCURATE	70%	75%	75%	97%

+ Determined by Ministry of the Environment field investigations.
* Model to predict known status lakes from Question 5, cottager level data.
** Model to predict known status from several variables, cottager level data.
*** Model to predict known status from Question 5, averaged scores for each lake.
**** Model to predict known status from aggregate level data (average scores) in a multivariate model.

3.4 DISCUSSION

The prediction results for filamentous algae, with 97% accuracy, were regarded as satisfactory to create a new variable: PREDICTED FILAMENTOUS ALGAE STATUS.

This variable is generated for those lakes sampled for which the filamentous algae status is unknown, and is used in subsequent sections of the report as a proxy for actual filamentous algae status, in examinations of such matters as impact of filamentous algae, and incidence. It is also examined, along with actual filamentous algae status in relation to acid sensitivity.

The achievement of the 97% accuracy rate for predictions, appears to verify the initial assumptions of the study, that a predictive model could be developed using cottager perceptions, in place of more costly scientific field studies.

These predictions are useful, but must be regarded as one more step in the Ministry's ongoing development of knowledge about lake conditions. Further research should provide insights for the development of more refined predictive models that would incorporate other water chemistry information, allow extension of predictions to unpopulated lakes, and help to explain the causal factors contributing to emergence of filamentous algae.

Chapter 4. Predicting the Presence of Odour Algae in Recreational Lakes

4.1 INITIAL PREDICTIONS: THE PILOT STUDY RESULTS RECAPITULATED

Generally, the pilot study predictions (which relied exclusively on cottager level data) were less successful for odour algae than those for filamentous algae. These basic (cottager level) predictions remain unchanged in this report, since the number of "known status" odour algae lakes remained at 10 for the main study. As previously discussed, overall success for the pilot predictions was 7 of 10 lakes, or 70% correctly predicted for the core question model, and 9 of 10, or 90% correctly predicted for the multivariate model. But the success rate was far less satisfactory for lakes known to have "some" odour algae: the core question model predicted only 1 of 3 of these "some" algae lakes correctly; and the multivariate model predicted only 2 of 3 correctly.

4.2 PREDICTING THE PRESENCE OF ODOUR ALGAE FROM AGGREGATE LEVEL DATA

Two aggregate level models were examined for odour algae, on the basis of the success obtained with filamentous algae. Although no new data were available on known status of lakes, aggregation did allow somewhat different treatment of the same data collected for the pilot study.

4.2.1 Method of Aggregating Data

Because of the small number of lakes for which odour status was known (10 lakes), statistical analysis at the aggregate level had to be approached somewhat differently (see Display 4.1).

These aggregated data models were all conducted on the basis of the 5-group aggregation in much the same manner as was done for the aggregated data model for filamentous algae. Average scores were computed for each of the odour-related variables, for up to five groups for each lake, where the five groups were defined on the basis of self-rated awareness of lake conditions (Question 25, awareness, was chosen because of its potential as a control variable, but another characteristic might have provided equally satisfactory results). The analysis was kept to this level, since this could provide up to 50 cases (5 groups for each of the ten lakes, allowing statistical analysis). In contrast, aggregation to the level of one score per variable per lake, would allow only ten cases for the discriminant analysis -- too few for statistical treatment.

As in the case of filamentous algae, two discriminant analyses were tested, one to test the predictive power of a simple model using only the group averages for core perception question, and another allowing open entry of group average variables into a multi-variate model.

DISPLAY 4.1

STEPS IN AGGREGATION TO 5 SUB-GROUPS

STEP 1: Cottagers on each lake were sub-divided into 5 groups, on the basis of self-reported awareness of lake conditions.*

STEP 2: Averages for each variable are computed for each of the five awareness groups.

STEP 3: New aggregate level cases are generated, with each self-awareness sub-group constituting a new "case", e.g. for a given lake, cottagers reports are combined, by averaging, to produce the five new "cases". (See Appendix B.2 for details.)

STEP 4: One or more predictive variables are entered into a discriminant analysis to predict actual lake status (as determined previously by the Ministry of the Environment).

STEP 5: From the discriminant analysis equations, and each groups' average responses for the questions used as predictive variables, a predicted lake status is estimated for each sub-group on each lake.

STEP 6: For each lake, predicted algae status is determined by examining the sub-group predictions. Where most of the sub-groups are predicted as "NIL's," the lake is classified as a "NIL" algae lake. Where most of the sub-groups are classified as "SOME," the lake is classified as a "SOME" algae lake.

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*Awareness was chosen because of its potential as a control variable, but another characteristic might have provided equally satisfactory results.

4.2.2 A Single Score, One Variable Model to Predict Odour Algae (Average Scores for Question 15)

The aggregated model based on the core perception question, performed fairly well. That model predicted 6 of 7 "nil" algae lakes correctly, and 2 of 3 "some" lakes correctly -- an overall rate of 80% successful. It performed better than the core question model tested at the cottager level in the pilot study (70% correct overall), but not as well as the multivariate model tested at the cottager level, for the pilot study (90% correct overall).

4.2.3 A Final Aggregate/Multi-Variate Model for Odour Algae

Our final step was to test multivariate model aggregated odour data.

Surprisingly, the multivariate model* using aggregated data, provided the best predictions of any model. All ten lakes were correctly classified using this model, with no errors. (Predictive accuracy of all four odour models is noted in Display 4.2, below.)

DISPLAY 4.2

PREDICTING THE PRESENCE OF ODOUR ALGAE FROM VARIOUS PREDICTIVE MODELS: PERCENTAGE ACCURACY

	Cottager Level Models		Aggregate Level Models	
	Core Question*	Multivariate**	Core Question***	Multivariate****
Known Status+				
Nil	86%	100%	86%	100%
Some	33	66	66	100
TOTAL	70%	75%	75%	97%

\+ Determined by Ministry of the Environment field investigations.
* Model to predict known status lakes from Question 5, cottager level data.
** Model to predict known status from several variables, cottager level data.
*** Model to predict known status from Question 5, averaged scores for each lake.
**** Model to predict known status from aggregate level data (average scores) in a multivariate model.

*Variables in the multivariate model were means scores for: ever noticed odour algae (Q.15); noticed in Aug. 1985; algae odour strong (Q.18); noticed odour in drinking water frequently (Q.21b); lake misperception variable (computed from misperception factor score, see Section 2); concern for odour algae (Q.19); and noticed cabbage odour (Q.22a).

4.3 DISCUSSION

The final model tested to predict odour algae, the multivariate model based on aggregate data, proved to be very successful at predicting odour algae status of lakes where this status was known to the Ministry.

Accordingly, the model was used to predict a new variable PREDICTED ODOUR ALGAE STATUS, for each lake included in the main study. This variable is used throughout, in analysis of such matters as incidence, and (along with actual algae status) our examination of the relation of odour algae to acid conditions of lakes.

Overall, the odour algae results complement those for filamentous algae, in suggesting that the survey method is indeed relatively reliable for identification of algae status of lakes, where scientific field testing is too costly or not feasible for other reasons.*

The results should be interpreted with caution, however, because a smaller sample of lakes has been used to validate the model. This caution is warranted, because since with a small sample of lakes a highly accurate result may occur by chance when the actual accuracy would be perhaps 70% or 80%. These results should be verified through further investigations of selected predictions we have made regarding odour algae status of lakes.

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*This view -- that the aggregated data model provides valid predictions -- was supported by one additional finding which emerged in the final analysis. Throughout the study, the researchers searched in vain for a correlation between actual odour algae status and "a cabbage smell," which was identified by Ministry biologists as the most typical smell of C. breviturrita. In the aggregate data analysis cabbage smell emerged as strongly correlated with actual odour algae status ($r = .307$; significant at $p = .02$); and in the final analysis emerged as one of the predictive variables.

Chapter 5. Incidence of Algae and Acid Sensitivity of Lakes

5.1 INCIDENCE OF ALGAE

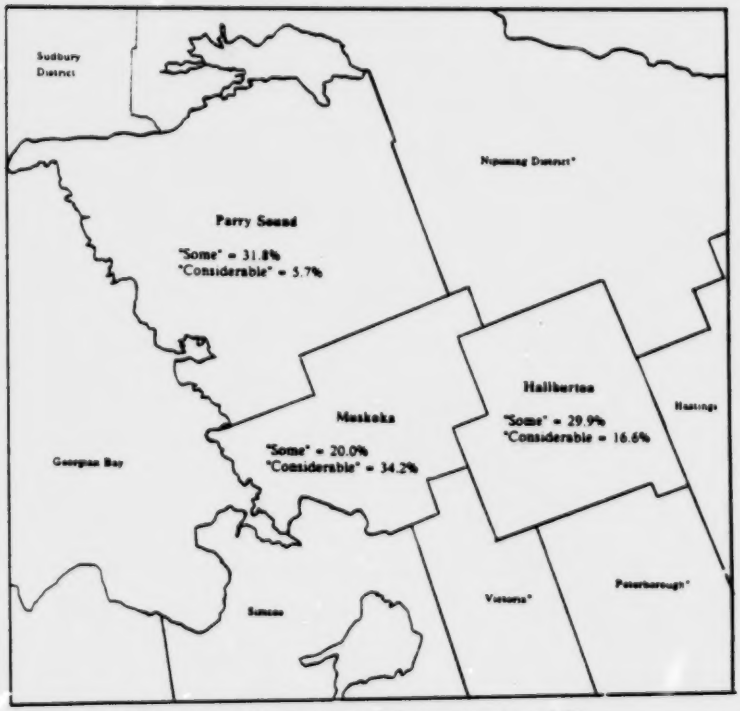
5.1.1 The Incidence of Filamentous Algae

The purpose of this analysis was to estimate the incidence of each type of algae for all Ontario recreational lakes. This was done by estimating the occurrence of each type of algae, using the discriminant analysis predictive model, with estimates then derived from the sample of lakes surveyed.

Estimates from our final predictive model indicated that some or considerable filamentous algae could be found on 47.7% of all lakes in the population of lakes surveyed. Of these lakes, 31.6% were estimated to have some filamentous algae, and 16.1% were estimated to have considerable filamentous algae. Incidence of filamentous algae appeared to be greatest in Muskoka District where a majority of populated lakes (54.2%) were estimated to have "some" or "considerable" filamentous algae; 34% of Muskoka lakes were estimated to have "considerable" filamentous algae. It is reasonable to assume that the incidence of filamentous algae for the population of all lakes surveyed is similar for lakes in Central Ontario which fall outside of this population (i.e. lakes with less than 10 cottages and unpopulated lakes).

DISPLAY 5.1

PREDICTED INCIDENCE OF FILAMENTOUS ALGAE BY DISTRICT, POPULATED LAKES
(shows % with "some" and "considerable" algae in main areas studied)



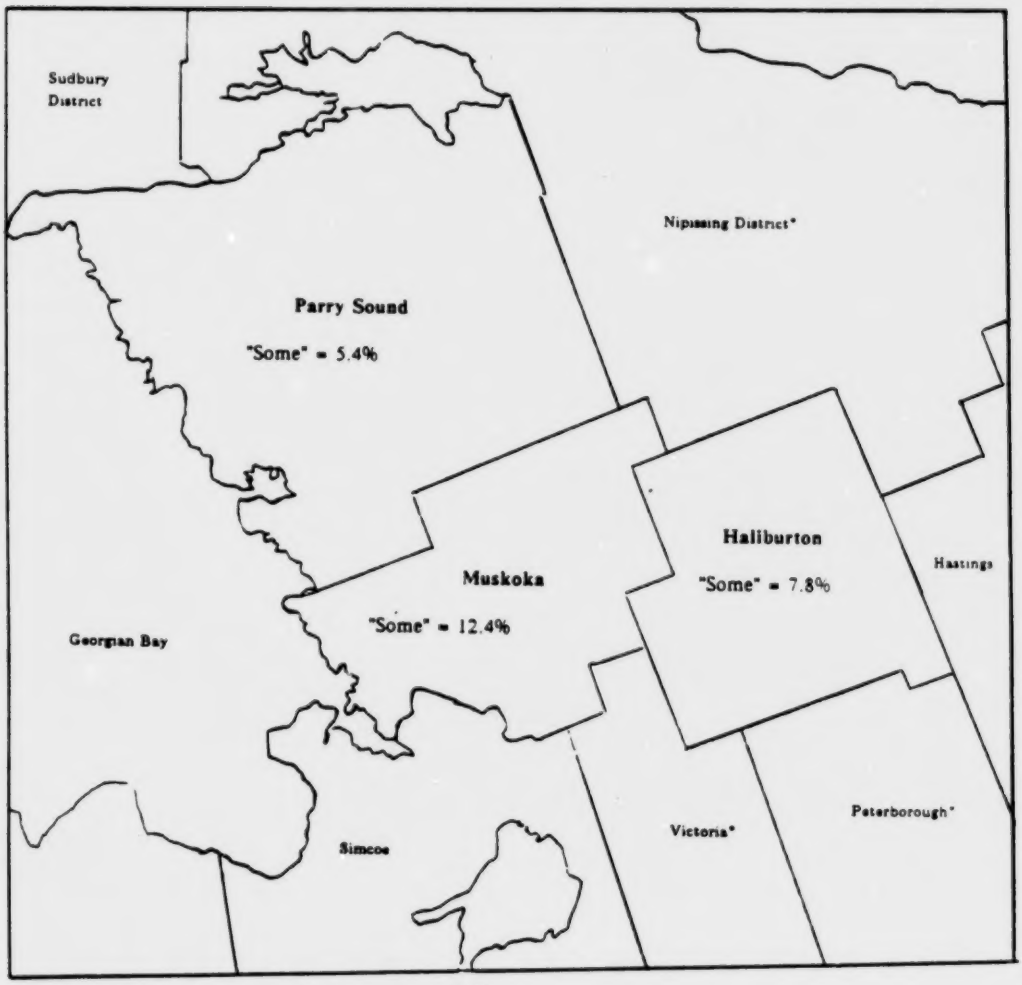
* In other districts, counties, "some" = 50.9%, "considerable = 9.2%.

5.1.2 The Incidence of Odour Algae

Survey estimates indicated far less presence of odour algae: some 6.1% of populated lakes were estimated to have odour algae. These were also more likely to be in Muskoka, where 12% of all lakes were estimated to have odour algae. It is reasonable to assume that the incidence of odour algae for the population of all lakes surveyed is similar for lakes in Central Ontario which fall outside of this population (i.e. lakes with less than 10 cottages, and unpopulated lakes).

DISPLAY 5.2

PREDICTED INCIDENCE OF ODOUR ALGAE BY DISTRICT
(shows % with "some" algae in main areas studied)



*In other districts/counties, some = 3.6%.

5.2 ALGAE AND ACID SENSITIVITY OF LAKES

5.2.1 Acidity and Algae: the Relationship Among Known Status Lakes

Because of the underlying concern with the relation of the two types of algae to lake acidification, the researchers examined in an exploratory way, the incidence of both types of algae in known algae status lakes of various acid sensitivity. This was also deemed to be important because of the high profile of acid rain in cottagers' perceptions of lake problems, as will be discussed in Chapter 6.

For the 32 known algae status lakes, we examined the apparent association between acid sensitivity level and the presence of filamentous algae. A substantial proportion of sensitivity 1 to 3 lakes (33 to 60%) had considerable filamentous algae; incidence of considerable filamentous algae declined consistently as acid sensitivity decreased (0.0% of the sensitivity 4 and 5 lakes had considerable filamentous algae).

DISPLAY 5.3

KNOWN FILAMENTOUS ALGAE STATUS BY LAKE ACID SENSITIVITY
(acid sensitivity level as a point of reference, data for 32 lakes)

	Known Filamentous Algae Status			
	Nil	Some	Considerable	Number of Lakes
MOST ACID				
Acid Sensitivity 1	66.7%	0.0%	33.3%	3
Acid Sensitivity 2	0.0	40.0	60.0	5
Acid Sensitivity 3	44.4	16.7	38.9	18
Acid Sensitivity 4	0.0	100.0	0.0	1
Acid Sensitivity 5	100.0	0.0	0.0	5
LEAST ACID				

An apparently stronger relation was suggested between acid sensitivity and known presence of odour algae. Incidence of odour algae declined dramatically, from 100% of the most acid lakes (sensitivity level 1) to 0% of the least acid sensitive lakes (sensitivity levels 4 and 5). Of course, since the data pertain to only ten lakes for which odour status is known, the association must be regarded as a very preliminary finding.

DISPLAY 5.4

KNOWN ODOUR ALGAE STATUS BY LAKE ACID SENSITIVITY
(acid sensitivity level as a point of reference, data for 10 lakes)

	Known Odour Algae Status		
	Nil	Some	Number of Lakes
MOST ACID			
Acid Sensitivity 1	0.0%	100.0%	1
Acid Sensitivity 2	66.7	33.3	3
Acid Sensitivity 3	66.7	33.3	3
Acid Sensitivity 4	--	--	0
Acid Sensitivity 5	100.0	0.0	3
LEAST ACID			

5.2.2 Acidity and Algae in Relation to Predicted Algae Status

Interestingly, these apparent relationships were also evidenced in our examination of acid sensitivity and predicted algae status (Displays 5.5 and 5.6 below). It is apparent from Display 5.5, that acid lakes (sensitivity level 1) are much more likely to be predicted to have considerable filamentous algae (75% as compared to 15% of sensitivity level 5 lakes).

Impact of lake acidity was also suggested in the association with predicted odour algae status. Of the most acid sensitive lakes, 25% were predicted to have some odour algae as compared to 0.0% of the least acid sensitive lakes.

DISPLAY 5.5

PREDICTED FILAMENTOUS ALGAE STATUS BY LAKE ACID SENSITIVITY
(acid sensitivity level as a point of reference, for a weighted N of 330 lakes)*

	Predicted Filamentous Algae Status			
	Nil	Some	Considerable	Number of Lakes
MOST ACID				
Acid Sensitivity 1	25.0%	0.0%	75.0%	4
Acid Sensitivity 2	33.3	43.4	23.3	56
Acid Sensitivity 3	59.2	25.9	14.9	186
Acid Sensitivity 4	61.4	28.2	10.4	50
Acid Sensitivity 5	35.5	49.0	15.5	34
LEAST ACID				

*See page 10 for a discussion of weights.

DISPLAY 5.6

PREDICTED ODOUR ALGAE STATUS BY LAKE ACID SENSITIVITY
(acid sensitivity level as a point of reference, weighted n of 330 lakes)*

	Predicted Odour Algae Status		
	Nil	Some	Number of Lakes
MOST ACID			
Acid Sensitivity 1	75.0%	25.0%	4
Acid Sensitivity 2	82.6	17.4	56
Acid Sensitivity 3	99.4	.6	186
Acid Sensitivity 4	98.9	1.1	50
Acid Sensitivity 5	100.0	0.0	34
LEAST ACID			

*See page 10 for a discussion of weights.

5.2.3 Discussion

The weight of this evidence strongly suggests an association between actual and predicted algae status and acid sensitivity. The validity and strength of this association, however, requires further research, since the statistical relationship is not estimated with precision in this exploratory analysis. This research could, with particular value, examine the interplay of known and predicted algae status with other water chemistry variables.

Chapter 6. Estimating the Impacts of Algae

As was noted in the introduction to this report, the pilot stage of this study indicated a number of negative impacts of algae which were reported by cottagers. This portion of the main study report is intended to examine impacts more closely, to assess the extent to which algae significantly affects cottagers' use and enjoyment of lakes.

6.1 SUBJECTIVE CONCERNS AND IMPACTS OF FILAMENTOUS ALGAE

Subjective impacts of filamentous algae were examined from several perspectives, as noted below (Displays 6.1 and 6.2).

6.1.1 Reported Impacts of Algae

In Display 6.1, cottagers reporting filamentous algae on their lakes are likely to identify a number of impacts of algae, especially on overall enjoyment, and aesthetic enjoyment of the lake. It is noteworthy that virtually all cottagers reporting algae (92%) indicated some level of concern with it.

DISPLAY 6.1

SUBJECTIVE IMPACTS OF FILAMENTOUS ALGAE
(shows % of cottagers reporting impacts for Q.13, and for each part of Q.14)

	COTTAGERS REPORTING ALGAE
Question 13: Concerned With Filamentous Algae	92.1%
Question 14 Sub-Questions: (ranked by concern of cottagers reporting filamentous algae)	
(f) Reduced aesthetic enjoyment of the lake and shore	74.0
(b) Reduced fish population	68.9
(c) Reduced enjoyment of swimming activity by you/your family	68.3
(a) Reduced overall enjoyment of the lake by you/your family	67.7
(d) Reduced enjoyment of boating by you/your family	28.2
(e) Affected health of you/your family	11.9
NUMBERS OF COTTAGERS	1,400*

*n varies somewhat from question to question.

6.1.2 Relative Seriousness of Filamentous Algae

To further examine the impacts of filamentous algae, we compared cottagers' assessments of filamentous algae as a problem, relative to other lake problems (Display 6.2 below).

In Display 6.2, acid rain emerges as the most serious lake problem for cottagers as a whole. But among those reporting presence of filamentous algae, algae is regarded as equally important. The data indicates that filamentous algae is seen as a serious problem for those reporting it. It is ranked first of eight among these cottagers, similar to the importance cottagers attribute to acid rain. But because a minority are exposed to this algae, its not yet seen as a serious problem among Ontario cottagers in general (i.e. ranked as the sixth most serious problem of eight, for all cottagers). This also suggests that the impacts of filamentous algae require closer examination on the specific lakes where it is found.

DISPLAY 6.2

COTTAGERS' RATINGS OF SERIOUS PROBLEMS
IN RELATION TO FILAMENTOUS ALGAE
(ranked by % of cottagers reporting algae who perceive a serious problem;
numbers appearing in brackets next to the "all cottagers" column indicates
the rank order of the problem as seen by all cottagers)

Q.23, % identifying as a problem	COTTAGERS REPORTING ALGAE	ALL COTTAGERS
(e) Filamentous algae	66.3%	29.1% (6)
(d) Acid rain affecting the lake	66.1	60.3 (1)
(f) Poor or declining quality of lake water	58.3	49.2 (2)
(g) Dead fish or declining fish population	36.5	36.0 (3)
(a) Too much recreational activity	27.1	32.8 (4)
(b) Too much shoreline development	26.5	30.0 (5)
(c) Poor or declining aesthetic appearance of the lake and shoreline	25.4	23.0 (7)
(h) Algae odour	16.9	12.5 (8)
NUMBERS OF COTTAGERS	1,400*	4,407*

*n varies somewhat from question to question.

6.2 SUBJECTIVE IMPACT OF ODOUR ALGAE

Subjective assessments of odour algae were very similar to assessments provided for filamentous algae (Displays 6.3 and 6.4 below).

6.2.1 Reported Impacts of Odour Algae

In Display 6.3, substantial proportions of cottagers who reported odour algae also reported negative impacts, particularly on overall enjoyment and swimming. A number of cottagers were also of the belief that algae had negatively affecting fish populations. As was found with filamentous algae, virtually all cottagers reporting presence of algae were concerned about it (91%).

DISPLAY 6.3

SUBJECTIVE IMPACTS OF ODOUR ALGAE

	COTTAGERS REPORTING ALGAE
Question 19: Concern About Odour Algae	91.1%
Question 20 Sub-Questions: (ranked by concern of cottagers reporting odour algae)	
(a) Reduced overall enjoyment of the lake by you/ your family	73.6
(c) Reduced enjoyment of swimming activity by you/ your family	70.8
(f) Reduced aesthetic enjoyment of the lake and shore	64.1
(b) Reduced fish population	56.7
(d) Reduced enjoyment of boating by you/your family	35.3
(e) Affected health of you/your family	19.5
NUMBERS OF COTTAGERS	413*

*n varies somewhat from question to question.

6.2.2 Relative Seriousness of Odour Algae

Display 6.4 below illustrates the same pattern of ratings of seriousness of problems: ratings of odour algae as a serious problem was very high among cottagers reporting odour algae (although behind concerns with acid rain and overall water quality).

The data indicates that odour algae is seen as a serious problem for those reporting it. It is ranked first of eight, similar to the importance cottagers attribute to acid rain. But because a very small minority are exposed to this algae, it is not yet seen as a serious problem among Ontario cottagers in general (i.e. ranked as the sixth most serious problem of eight, for all cottagers). Again, this points towards the need for closer examination of the situation on the specific lakes where the algae is present.

DISPLAY 6.4

COTTAGERS' RATING OF SERIOUS PROBLEMS IN RELATION TO ODOUR ALGAE
(ranked by % of cottagers reporting algae, who perceive a serious problem; numbers appearing in brackets next to the "all cottagers" column indicates the rank order of the problem as seen by all cottagers)

Q.23: % IDENTIFYING AS A PROBLEM	COTTAGERS REPORTING ALGAE	ALL COTTAGERS
(f) Poor or declining quality of lake water	61.8%	49.2% (2)
(d) Acid rain affecting the lake	58.9	60.3 (1)
(h) Algae odour	52.2	12.5 (8)
(e) Filamentous algae	47.1	29.1 (6)
(g) Dead fish or declining fish population	33.4	36.2 (3)
(a) Too much recreational activity	25.0	32.8 (4)
(b) Too much shoreline development	21.5	30.0 (5)
(c) Poor or declining aesthetic appearance of the lake and shoreline	21.3	23.0 (7)
NUMBERS OF COTTAGERS	413*	4,407*

*n varies somewhat from question to question.

Together, these findings of reported impacts of filamentous and odour algae lead us to look more closely, in the section to follow, at the factors which underly reports of impact, and which thus affect the way we assess their validity.

6.3 VALIDATING EVIDENCE OF IMPACTS OF ALGAE: A MULTIVARIATE TEST

6.3.1 Impact on Overall Lake Satisfaction

One analysis undertaken to examine impacts in greater detail was a regression to determine the impact of odour and filamentous algae on overall lake satisfaction (Question 4) in comparison to other lake concerns. The results (Display 6.5) suggest that concern regarding filamentous algae (Q.13) and concern with odour algae are determinants of satisfaction. But these effects appear to be modest, as suggested by the size of the Beta coefficients, and overall predictive accuracy of the regression (an R-square of .157, suggests that all of these factors together only account for about 16% of the variance in satisfaction).

DISPLAY 6.5

PREDICTING SATISFACTION: REGRESSION RESULTS
Significant coefficients at P <.01 indicated by *

Variables	Beta** Coefficient
Q3(c) Concern with poor or declining quality of lake water for swimming and other forms of water recreation	-.108*
Q3(a) Concern with dead fish or declining fish population	-.104*
Q3(b) Concern with poor or declining quality of lake water for drinking and cooking	-.091*
Q19 Concern with odour algae	-.087*
Q13 Concern with filamentous algae	-.089*
Q3(f) Concern with poor or declining aesthetic appearance of the lake and shoreline	-.064*
Q3(h) Concern with too much shoreline development	NS
Q3(e) Concern with water level fluctuation	NS
Q3(d) Concern with acid rain affecting the lake	NS
Q3(g) Concern with too much recreational activity	NS

**Indicates significance of prediction: NS = coefficient not significant; R-square = .157.

6.3.2 Discussion

The initial indications of impact as reported by cottagers suggested that algae impacts are substantial. Yet the linkage to reported lake satisfaction appears to be modest. These results lead us to conclude that further research may be required on algae impacts, to ascertain their significance.

Chapter 7. Summary and Conclusion

7.1 RESULTS

The study demonstrated the feasibility of predicting the presence of filamentous algae and odour producing algae from an attitude survey of cottagers, and provided additional data on incidence, impacts and relation to acid sensitivity in a study of 214 central Ontario recreational lakes.

Predictive power of the study models, relying on aggregated (average score) data, and using discriminant analysis, was excellent, allowing accurate prediction of 97% of the 32 known status filamentous algae lakes, and accurate prediction of odour algae status of all 10 of the known status odour algae lakes.

Examination of incidence of algae and relation to lake acid sensitivity indicated: (1) that filamentous algae may be found in a little under half of Central Ontario recreational lakes (47.7%), and that odour algae may be found in about 6% of Central Ontario's recreational lakes. Both types of algae were apparently more likely to be found in more acid sensitive lakes.

Examination of impacts of algae suggested a number of important concerns reported by cottagers, including substantial impacts on aesthetic enjoyment, swimming and overall enjoyment of the lake. These data provide a general indication of how algae may impact lake use and enjoyment. Further investigation is warranted to more accurately identify the specific nature and magnitude of such impacts.

7.2 LIMITATIONS OF THE STUDY METHOD

While the study results are regarded as highly satisfactory, they must be regarded as exploratory in a number of ways. First, the validation of the predictive models is an on-going activity which should be incorporated in the Ministry's future research program. These initial results must be regarded as indicative, and not definitive. This is expecially true for the results for odour algae, since the odour predictions have been based on known algae status data for a very small sample of lakes.

Further research will be desirable to validate certain of these findings. Related research would examine reliability of predictions and the power of predictive models that may include additional water chemistry data and extend the inventory of lakes classified as to predicted algae status.

The relation of lake acid sensitivity to incidence of both types of algae, as suggested by these findings may be important in two respects: (1) in helping to clarify the causality behind emergence of algae -- where lake acidity appears to contribute to the emergence of both types of algae; and (2) in building better predictive models that may be based on water chemistry data, such as acid sensitivity, as well as on cottager reports.

APPENDIX A
QUESTIONNAIRE

OFFICE USE: _ _ _ ··· _ _ _ _ _

LAKE _____

SURVEY ON RECREATIONAL LAKE QUALITY AND ALGAE

Ontario Ministry of the Environment

PURPOSE OF THE SURVEY

The objective of this survey is to provide the Ministry of the Environment with new information on attitudes of cottagers (and permanent lakeside residents) as to the conditions of Ontario's recreational lakes. The survey is important because it will help the Ministry to evaluate key issues relevant to improving or maintaining the quality of Ontario's recreational lakes.

INSTRUCTIONS

The survey will only take 10 to 15 minutes to complete.

For most questions: Simply indicate your answer by checking the box next to the answer which is most correct for your lake, or write in the answer which is correct for you.

For special 1 to 5 rating scales:

Some questions ask you to indicate your answer on a 5-point scale, for example:

Q. Is the quality of recreational lakes unimportant or important to lake users?

NOT AT ALL IMPORTANT 1 2 3 4 5 EXTREMELY IMPORTANT

To answer such a question, you would circle the

"1" if you thought the best answer was "NOT AT ALL IMPORTANT",

"2" would indicate that the answer was "NOT PARTICULARLY IMPORTANT",

"3" if you thought the best answer was "IN-BETWEEN", or if you weren't sure,

"4" to indicate that the answer was "VERY IMPORTANT",

"5" if you thought the best answer was "EXTREMELY IMPORTANT".

If an answer we have provided does not explain everything you want to tell us, please check or circle the "best" answer we have provided, and then write in any extra comments you have.

SKIP INSTRUCTIONS: Some of the answers you check or circle are followed by instructions to "go to" a question number or section further on in the questionnaire. This means you should "skip" a set of questions which will not apply to your situation. Please follow these carefully, and only skip where the specific answer you check or circle is followed by a skip instruction.

PLEASE FILL OUT THE QUESTIONNAIRE AND MAIL IT BACK AS SOON AS POSSIBLE.

THANK YOU FOR YOUR ASSISTANCE WITH THIS STUDY.

SECTION A. LAKE UTILIZATION

1. How long have you owned your cottage or lakeside residence, or otherwise been a user of this lake?

_____ Years OR (_____ Months)

2. Do you use your cottage or lakeside residence: (CHECK ONE)

- ☐ In Summer only
- ☐ Summer and occasional Winter use (2-3 times)
- ☐ Regularly throughout the year including Summer, Winter, Fall and Spring

3. Which of the following concerns (if any) have you had about your lake during the past 5 years? (CHECK ONE BOX FOR EACH OF (a) TO (i))

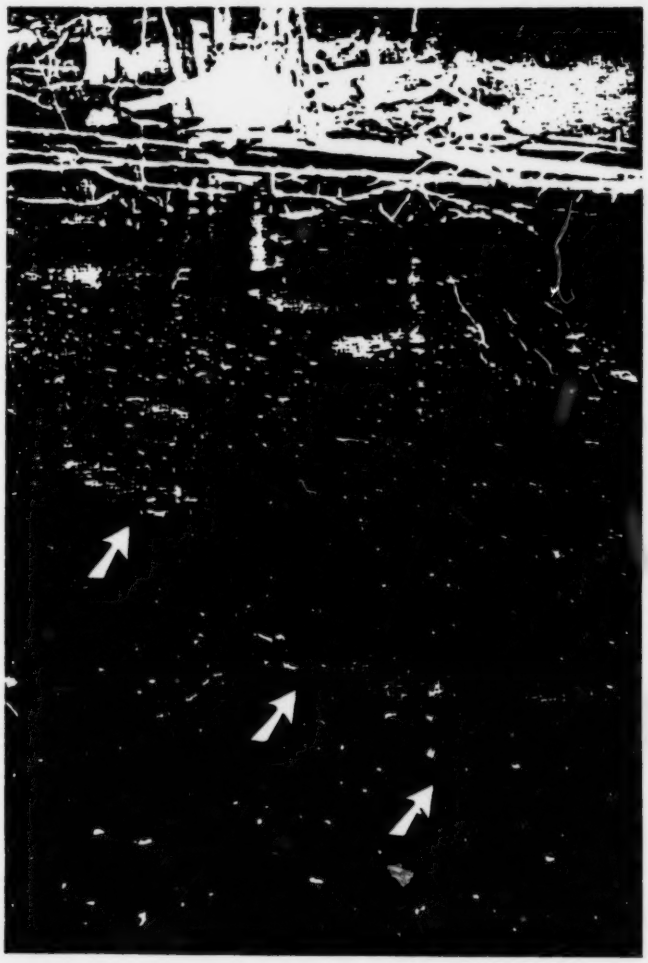
ITEM	NO CONCERN	SOME CONCERN	GREAT CONCERN	DON'T KNOW
(a) Dead fish or declining fish population in your lake	☐	☐	☐	☐
(b) Poor or declining quality of lake water for drinking and cooking	☐	☐	☐	☐
(c) Poor or declining quality of lake water for swimming and other forms of water recreation	☐	☐	☐	☐
(d) Acid rain affecting the lake	☐	☐	☐	☐
(e) Water level fluctuation	☐	☐	☐	☐
(f) Poor or declining aesthetic appearance of the lake and shoreline	☐	☐	☐	☐
(g) Too much recreational activity	☐	☐	☐	☐
(h) Too much shoreline development	☐	☐	☐	☐
(i) Other (PLEASE SPECIFY): _____	☐	☐	☐	☐

4. Overall, how satisfied are you with your lake? (CIRCLE ONE NUMBER)

VERY SATISFIED 1 2 3 4 5 VERY DISSATISFIED

SECTION B. FILAMENTOUS ALGAE

Many lakes have a type of algae which is called FILAMENTOUS ALGAE, which usually looks something like the picture below. It is often described as "clouds of algae", or "cotton candy clouds".



These filamentous algae may occur as:

- Clouds the size of baseballs or as large as a table.
- Tangled masses around rooted plants in the water, logs, or other shoreline objects.

This type of algae is easy to recognize because it feels like slimy wet hair.

5. Have you/your family ever noticed filamentous algae in your lake? (CIRCLE ONE NUMBER)

UNCERTAIN

DEFINITELY YES 1 2 3 4 5 DEFINITELY NOT

(GO TO SECTION C ON PAGE 4)

6. How would you describe the colour of this type of algae? (CHECK OFF AS MANY AS YOU THINK APPLY)

- ☐ Pale greenish grey (like the above picture)
- ☐ Bright yellow green
- ☐ Dark green
- ☐ Rosey or purple
- ☐ Other
- ☐ DON'T KNOW

7. Of the colour(s) you have checked off above, CIRCLE the one you think is most common.

8. In which of the past several years, have you/your family noticed filamentous algae in your lake?
(CHECK ONE BOX FOR EACH YEAR)

	DEFINITELY NOT PRESENT	POSSIBLY PRESENT	DEFINITELY PRESENT	DON'T KNOW
1985	☐	☐	☐	☐
1984	☐	☐	☐	☐
1983	☐	☐	☐	☐
1982	☐	☐	☐	☐
1981	☐	☐	☐	☐
1980 or earlier	☐	☐	☐	☐

9. If filamentous algae were noticed by you/your family in 1985, in which of the following months was it seen?
(CHECK ONE BOX FOR EACH MONTH)

	DEFINITELY NOT PRESENT	POSSIBLY PRESENT	DEFINITELY PRESENT	DON'T KNOW
In May, 1985	☐	☐	☐	☐
In June, 1985	☐	☐	☐	☐
In July, 1985	☐	☐	☐	☐
In August, 1985	☐	☐	☐	☐

10. In general, over the past 5 years how noticeable have filamentous algae been in your lake?
(CIRCLE ONE NUMBER)

THIS TYPE OF ALGAE HAS BEEN VERY NOTICEABLE 1 2 3 4 5 THIS TYPE OF ALGAE HAS NOT BEEN NOTICEABLE

11. Over the past 5 years, have the filamentous algae usually been present in: (CHECK ONE ANSWER IN EACH OF COLUMNS (1) TO (3))

COLUMN 1	COLUMN 2	COLUMN 3
☐ Only a few parts of the lake	☐ Only at the bottom	☐ Only at the shore
☐ Many parts of the lake	☐ Only at the surface	☐ Only away from shore
☐ All of the lake	☐ From surface to bottom	☐ From shore to deep water
☐ DON'T KNOW	☐ DON'T KNOW	☐ DON'T KNOW

12. Have you or any member of your family ever picked up filamentous algae (by hand, with a stick or paddle, etc.?)
(CHECK ONE)

☐ Yes
☐ No
☐ DON'T KNOW

13. In general, how concerned have you/your family been about filamentous algae in your lake?
(CIRCLE ONE NUMBER)

NO CONCERN 1 2 3 4 5 EXTREME CONCERN

14. Do you believe the presence of filamentous algae has: (CHECK ONE BOX FOR EACH OF (a) TO (g))

	NOT AT ALL	A LITTLE	A FAIR AMOUNT	A GREAT DEAL	UNCERTAIN
(a) Reduced overall enjoyment of the lake by you/your family	☐	☐	☐	☐	☐
(b) Reduced fish population	☐	☐	☐	☐	☐
(c) Reduced enjoyment of swimming activity by you/your family	☐	☐	☐	☐	☐
(d) Reduced enjoyment of boating by you/your family	☐	☐	☐	☐	☐
(e) Affected health of you/your family	☐	☐	☐	☐	☐
(f) Reduced aesthetic enjoyment of the lake and shore	☐	☐	☐	☐	☐
(g) Other (PLEASE SPECIFY): _____	☐	☐	☐	☐	☐

SECTION C. ODOUR ALGAE

Some lakes have a type of microscopic algae (which we will call "ODOUR ALGAE" for short). These algae cannot be seen by the naked eye but have a very distinct odour, similar to that of cooking cabbage or a very "ripe" compost heap.

15. Have you/your family ever noticed this type of odour in your lake? (CIRCLE ONE NUMBER)

UNCERTAIN

DEFINITELY YES 1 2 3 4 5 DEFINITELY NOT

(GO TO SECTION D ON PAGE 6)

16. In which of the past several years, have you/your family noticed this odour in your lake? (CHECK ONE BOX FOR EACH YEAR)

	DEFINITELY NOT PRESENT	POSSIBLY PRESENT	DEFINITELY PRESENT	DON'T KNOW
1985	☐	☐	☐	☐
1984	☐	☐	☐	☐
1983	☐	☐	☐	☐
1982	☐	☐	☐	☐
1981	☐	☐	☐	☐
1980 or earlier	☐	☐	☐	☐

17. If you/your family noticed the odour in 1985, in which months was it noticed?
(CHECK ONE BOX FOR EACH MONTH)

	DEFINITELY NOT PRESENT	POSSIBLY PRESENT	DEFINITELY PRESENT	DON'T KNOW
In May, 1985	☐	☐	☐	☐
In June, 1985	☐	☐	☐	☐
In July, 1985	☐	☐	☐	☐
In August, 1985	☐	☐	☐	☐

18. In general, over the past 5 years how strong has the algae odour been on your lake? (CIRCLE ONE NUMBER)

ODOUR HAS BEEN STRONG 1 2 3 4 5 ODOUR HAS BEEN MILD

19. In general, how concerned have you/your family been about how strong the algae odour has been?
(CIRCLE ONE NUMBER)

NO CONCERN 1 2 3 4 5 EXTREME CONCERN

20. Do you believe the presence of this algae odour has: (CHECK ONE BOX FOR EACH OF (a) TO (g))

	NOT AT ALL	A LITTLE	A FAIR AMOUNT	A GREAT DEAL	DON'T KNOW
(a) Reduced overall enjoyment of the lake by you/your family	☐	☐	☐	☐	☐
(b) Reduced fish population	☐	☐	☐	☐	☐
(c) Reduced enjoyment of swimming activity by you/your family	☐	☐	☐	☐	☐
(d) Reduced enjoyment of boating by you/your family	☐	☐	☐	☐	☐
(e) Affected health of you/your family	☐	☐	☐	☐	☐
(f) Reduced aesthetic enjoyment of the lake and shore	☐	☐	☐	☐	☐
(g) Other (PLEASE SPECIFY): _____	☐	☐	☐	☐	☐

SECTION D. OTHER LAKE CHARACTERISTICS

21. Please note how frequently you/your family have noticed the following kinds of things about your lake in the past five years. (CHECK ONE BOX FOR EACH OF (a) TO (j))

	NEVER NOTICED	NOTICED OCCASIONALLY	NOTICED MANY TIMES	NOTICE ALWAYS
(a) Slippery invisible film on rocks	☐	☐	☐	☐
(b) Odour or strong taste in drinking water	☐	☐	☐	☐
(c) Brown colour in lake water	☐	☐	☐	☐
(d) Green scum on lake water	☐	☐	☐	☐
(e) Yellow scum on lake water	☐	☐	☐	☐
(f) Clouds of algae (like cotton candy) in water	☐	☐	☐	☐
(g) Slippery green slime on rocks, logs, docks	☐	☐	☐	☐
(h) Vegetation in the water (growths with stems, leaves etc.)	☐	☐	☐	☐
(i) Frothy white foam/suds on lake water	☐	☐	☐	☐
(j) Large numbers of dead fish	☐	☐	☐	☐

22. A lake may have various kinds of odours. People often use different words to describe such odours. Please indicate below to what extent these odours may have been present in your lake at any time during the past 5 years. (CHECK ONE BOX FOR EACH OF (a) to (g).

	NEVER NOTICED	NOTICED OCCASIONALLY	NOTICED MANY TIMES	NOTICE ALWAYS
(a) Cooking cabbage	☐	☐	☐	☐
(b) Grassy, musty	☐	☐	☐	☐
(c) Fishy	☐	☐	☐	☐
(d) Septic, sewage	☐	☐	☐	☐
(e) Rotten garbage	☐	☐	☐	☐
(f) Something dead/decaying	☐	☐	☐	☐
(g) Other (PLEASE SPECIFY):				
_____	☐	☐	☐	☐

23. Please rate the seriousness of the following problems in your lake by identifying the FOUR most serious problems. (PLACE A "1" NEXT TO THE MOST SERIOUS PROBLEM, A "2" NEXT TO THE SECOND MOST SERIOUS, A "3" NEXT TO THE THIRD MOST SERIOUS, AND A "4" NEXT TO THE 4TH MOST SERIOUS).

___ Too much recreational activity

___ Too much shoreline development

___ Poor or declining aesthetic appearance of the lake and shoreline

___ Acid rain affecting the lake

___ Filamentous algae (shown in the photo on page 2)

___ Poor or declining quality of lake water

___ Dead fish or declining fish population

___ Algae odour

24. How often do you/your family participate in the following types of activities at your lake? (CHECK ONE BOX FOR EACH ACTIVITY)

ACTIVITY	NEVER OR RARELY	OCCASIONALLY (2-3 TIMES PER SUMMER)	FREQUENTLY (AT LEAST ONCE PER WEEK)
(a) Swimming/wading near shore	☐	☐	☐
(b) Sitting by water/enjoying the view	☐	☐	☐
(c) Motorboating/waterskiing	☐	☐	☐
(d) Canoeing/rowing/sailing	☐	☐	☐
(e) Fishing	☐	☐	☐

25. In general, how familiar would you consider yourself to be with the lake conditions on all different parts of your lake? (For example, you may fish in all parts of the lake, and know the weeds, water quality, currents, depths, etc.) (CIRCLE ONE NUMBER)

NOT AT ALL FAMILIAR 1 2 3 4 5 VERY FAMILIAR

THANK YOU FOR COMPLETING THIS IMPORTANT QUESTIONNAIRE. PLEASE FEEL FREE TO ATTACH A SHEET WITH ANY OTHER COMMENTS YOU MIGHT HAVE ABOUT YOUR LAKE. NOTE: If you want to receive a summary of the findings of this survey, please contact the nearest REGIONAL OFFICE of the ONTARIO MINISTRY OF THE ENVIRONMENT early in 1987.

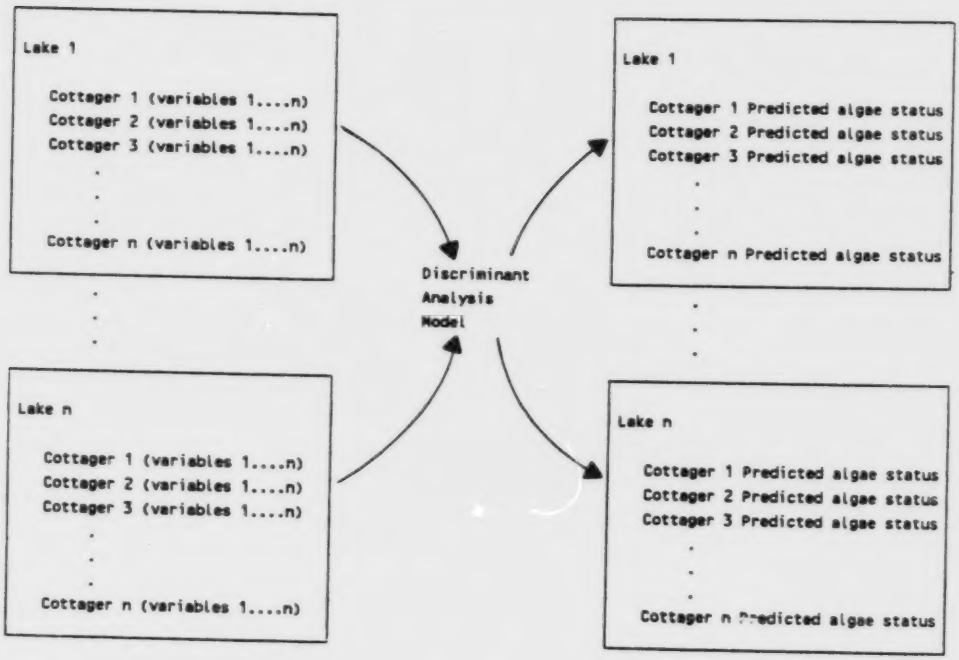
Please return this questionnaire as soon as possible in the enclosed postage-paid envelope.

APPENDIX B:
AGGREGATING DATA

Initial analyses of the study involved generation of predicted algae status scores for each cottager (see Display B.1 below). In this display, the discriminant analysis model uses the individual variables (question responses) for each cottager, to generate a predicted lake status score for each cottager.

DISPLAY B.1

PREDICTIONS AT THE COTTAGER LEVEL

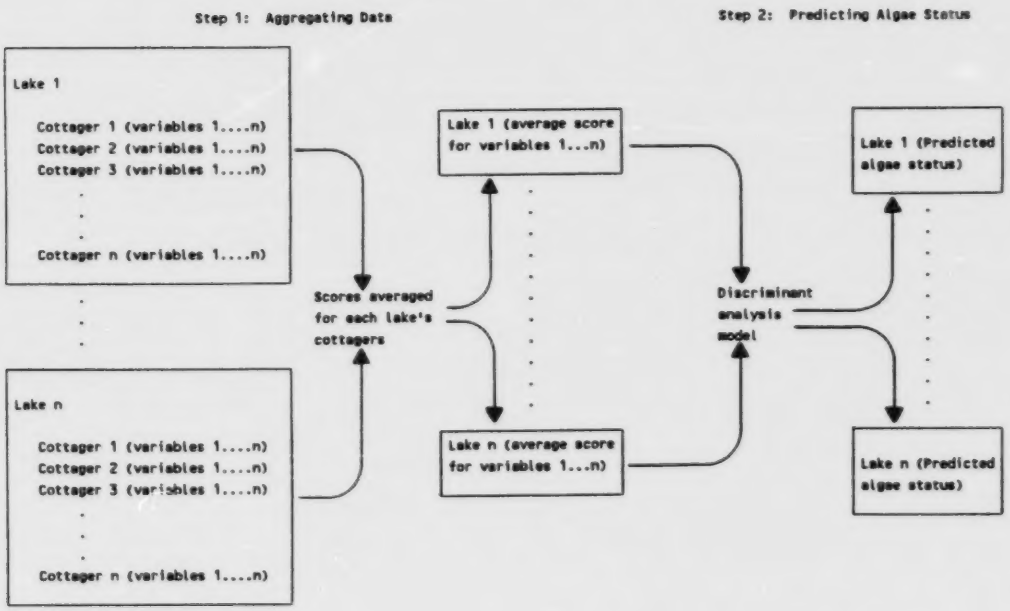

Lake 1
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Lake n
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Discriminant Analysis Model
Lake 1
Cottager 1 Predicted algae status
Cottager 2 Predicted algae status
Cottager 3 Predicted algae status
Cottager n Predicted algae status
Lake n
Cottager 1 Predicted algae status
Cottager 2 Predicted algae status
Cottager 3 Predicted algae status
Cottager n Predicted algae status

B.1 Aggregating Data to the Lake Level

The method for aggregating filamentous algae data to the lake level is simply that of averaging all of the data for cottagers for each lake, so that instead of each cottagers' data entering the analysis, each lake enters the analysis, with the average scores of cottagers for each lake providing the data for the discriminant analysis. This process is outlined in Display B.2 below, where we see that the same data shown in the previous display is first aggregated (Step 1) and then entered into the discriminant analysis (Step 2).

DISPLAY B.2

PREDICTIONS AT THE LAKE LEVEL


Step 1: Aggregating Data
Step 2: Predicting Algae Status
Lake 1
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Lake n
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Scores averaged for each lake's cottagers
Lake 1 (average score for variables 1...n)
Lake n (average score for variables 1...n)
Discriminant analysis model
Lake 1 (Predicted algae status)
Lake n (Predicted algae status)

B.2 Aggregating Data for the Odour Analysis

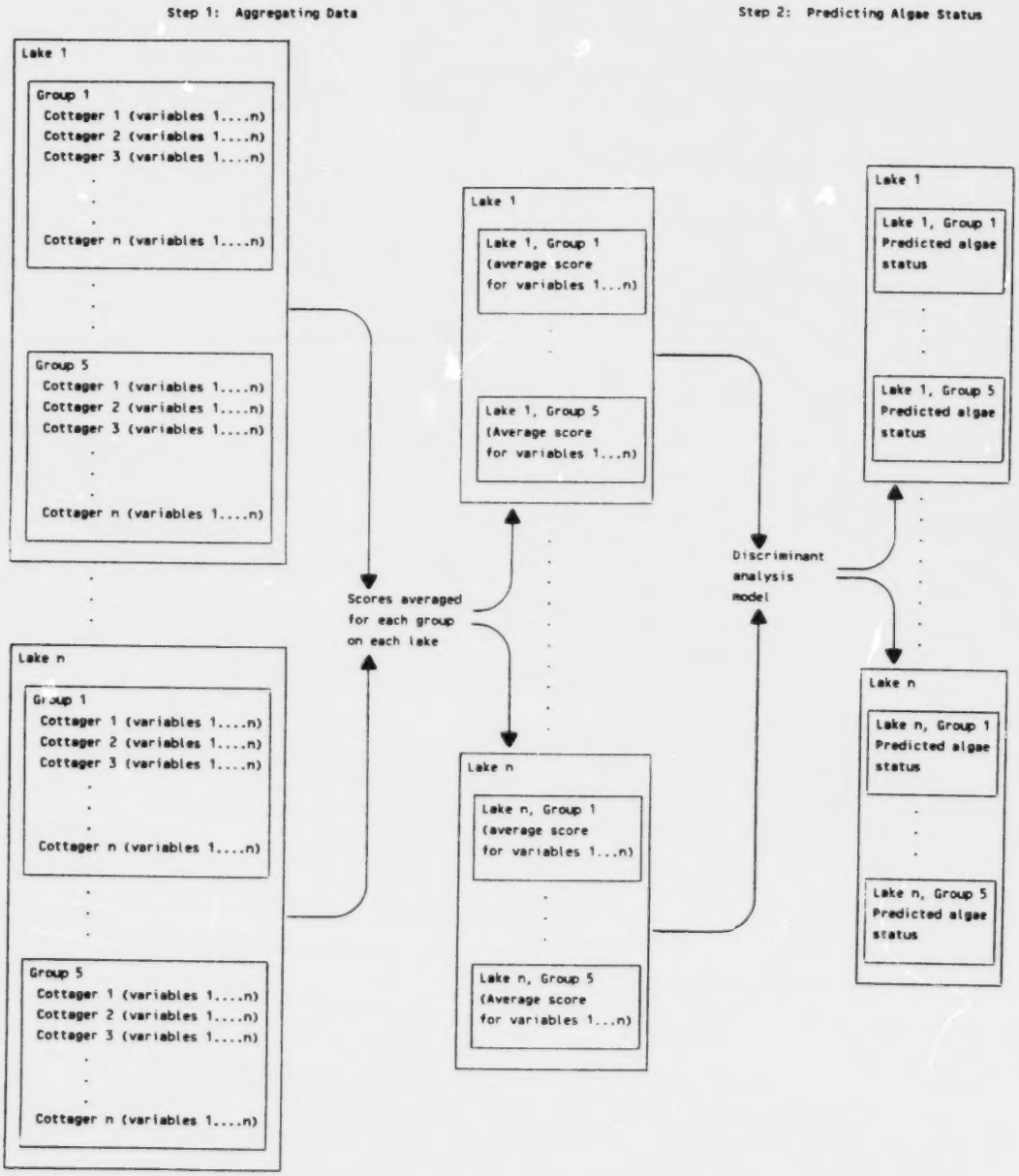
A somewhat different method was used for aggregating data for the odour analysis. Because only ten lakes had known status data vis-a-vis odour algae, aggregating to the lake level was seen as unsatisfactory, since too few cases would be provided for statistical analysis.

Accordingly, we proceeded in the following way, as suggested by Display B.3. Cottagers within each lake were grouped according to self-reported awareness of lake conditions, into five groups, as noted in step one below. Average scores were then generated for each of the groups for each lake. Discriminant analysis was then applied in the usual manner to the group scores, algae status being predicted for each lake-group combination in the discriminant analysis.

See next page for Display B.3

DISPLAY B.3

PREDICTIONS AT THE LAKE LEVEL


Step 1: Aggregating Data
Step 2: Predicting Algae Status
Lake 1
Group 1
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Group 5
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Lake n
Group 1
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Group 5
Cottager 1 (variables 1....n)
Cottager 2 (variables 1....n)
Cottager 3 (variables 1....n)
Cottager n (variables 1....n)
Scores averaged for each group on each lake
Lake 1
Lake 1, Group 1 (average score for variables 1...n)
Lake 1, Group 5 (Average score for variables 1...n)
Lake n
Lake n, Group 1 (average score for variables 1...n)
Lake n, Group 5 (Average score for variables 1...n)
Discriminant analysis model
Lake 1
Lake 1, Group 1 Predicted algae status
Lake 1, Group 5 Predicted algae status
Lake n
Lake n, Group 1 Predicted algae status
Lake n, Group 5 Predicted algae status

APPENDIX C
DESCRIPTIVE SURVEY RESULTS

DESCRIPTIVES Q1/STATISTICS = 1 10 11.

Number of Valid Observations (Listwise) = 4338.00

Variable	Mean	Minimum	Maximum	N	Label
Q1	17.93	.04	90.00	4338	How long have you been user of

FREQUENCIES Q2A TO Q5.

Q2A When do you use your cottage/res.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Summer only	1.00	1466	33.3	33.7	33.7
Summer & some winter	2.00	1453	33.0	33.4	67.1
All year round	3.00	1431	32.5	32.9	100.0
	.	57	1.3	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4350 Missing Cases 57

Q3A Concern about dead-declining fish pop.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	1140	25.9	30.5	30.5
Some concern	2.00	1492	33.9	40.0	70.5
Great concern	3.00	1100	25.0	29.5	100.0
	.	416	9.4	MISSING	
Dont know	4.00	259	5.9	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3732 Missing Cases 675

Q3B Concern about poor water for drink-cook

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	1092	24.8	29.1	29.1
Some concern	2.00	1449	32.9	38.6	67.7
Great concern	3.00	1212	27.5	32.3	100.0
	.	429	9.7	MISSING	
Dont know	4.00	225	5.1	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3753 Missing Cases 654

Q3C Concern about poor water for recreation

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	1779	40.4	46.0	46.0
Some concern	2.00	1246	28.3	32.2	78.2
Great concern	3.00	843	19.1	21.8	100.0
	.	448	10.2	MISSING	
Dont know	4.00	91	2.1	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3868 Missing Cases 539

Q3D Concern about affect of acid rain

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	376	8.5	10.8	10.8
Some concern	2.00	1019	23.1	29.4	40.2
Great concern	3.00	2073	47.0	59.8	100.0
	.	340	7.7	MISSING	
Dont know	4.00	599	13.6	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3468 Missing Cases 939

Q3E Concern about water level fluctuation

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	1447	32.8	36.7	36.7
Some concern	2.00	1459	33.1	37.0	73.6
Great concern	3.00	1042	23.6	26.4	100.0
	.	381	8.6	MISSING	
Dont know	4.00	78	1.8	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3948 Missing Cases 459

Q3F Concern about poor appearance of water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	2171	49.3	57.2	57.2
Some concern	2.00	1108	25.1	29.2	86.4
Great concern	3.00	516	11.7	13.6	100.0
	.	496	11.3	MISSING	
Dont know	4.00	116	2.6	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3795 Missing Cases 612

Q3G Concern about too much recr. activity

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	2133	48.4	54.4	54.4
Some concern	2.00	1321	30.0	33.7	88.1
Great concern	3.00	467	10.6	11.9	100.0
	.	437	9.9	MISSING	
Dont know	4.00	49	1.1	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3921 Missing Cases 486

Q3H Concern about too much shoreline dev.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	2183	49.5	56.4	56.4
Some concern	2.00	1154	26.2	29.8	86.2
Great concern	3.00	535	12.1	13.8	100.0
	.	468	10.6	MISSING	
Dont know	4.00	67	1.5	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 3872 Missing Cases 535

Q3I Concern about other problems

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No concern	1.00	10	.2	2.0	2.0
Some concern	2.00	87	2.0	17.8	19.9
Great concern	3.00	391	8.9	80.1	100.0
	.	3910	88.7	MISSING	
Dont know	4.00	9	.2	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 488 Missing Cases 3919

Q4 Overall satisfaction with lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Very Satisfied	1.00	1210	27.5	28.2	28.2
	2.00	1515	34.4	35.2	63.4
	3.00	1062	24.1	24.7	88.1
	4.00	336	7.6	7.8	95.9
Very Dissatisfied	5.00	175	4.0	4.1	100.0
	.	109	2.5	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4298 Missing Cases 109

Q5 Rating ever noticed filamentous algae

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Definitely Yes	1.00	1133	25.7	25.7	25.7
	2.00	432	9.8	9.8	35.6
Uncertain	3.00	569	12.9	12.9	48.5
	4.00	159	3.6	3.6	52.1
Definitely Not	5.00	2109	47.9	47.9	100.0
	.	5	.1	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4402 Missing Cases 5

PROCESS IF (Q5 LE 4).
FREQUENCIES Q6PALE TO Q14G2.

Q6PALE Filamentous algae is pale greenish grey

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Yes	1.00	1371	59.8	67.2	67.2
No	2.00	670	29.2	32.8	100.0
	.	252	11.0	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2041 Missing Cases 252

Q6BRIGHT Filamentous algae is bright yellow green

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Yes	1.00	416	18.1	20.4	20.4
No	2.00	1624	70.8	79.6	100.0
	.	253	11.0	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2040 Missing Cases 253

Q6DARK Filamentous algae is dark green

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Yes	1.00	619	27.0	30.3	30.3
No	2.00	1421	62.0	69.7	100.0
	.	253	11.0	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2040 Missing Cases 253

Q6ROSEY Filamentous algae is rosey or purple

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Yes	1.00	18	.8	.9	.9
No	2.00	2022	88.2	99.1	100.0
	.	253	11.0	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2040 Missing Cases 253

Q6OTHER Filamentous algae is other colour

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Yes	1.00	85	3.7	4.2	4.2
No	2.00	1955	85.3	95.8	100.0
	.	253	11.0	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2040 Missing Cases 253

Q6DK Dont know the colour of fil. algae

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Yes	1.00	217	9.5	10.7	10.7
No	2.00	1819	79.3	89.3	100.0
	.	257	11.2	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2036 Missing Cases 257

Q7 Most common colour

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Grey-Green	1.00	879	38.3	38.3	38.3
Other	2.00	1414	61.7	61.7	100.0
	TOTAL	2293	100.0	100.0	

Valid Cases 2293 Missing Cases 0

Q81985 Noticed filamentous algae on lake-1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	789	34.4	34.4	34.4
Possibly Present	2.00	403	17.6	17.6	52.0
Definitely Present	3.00	1101	48.0	48.0	100.0
	TOTAL	2293	100.0	100.0	

Valid Cases 2293 Missing Cases 0

Q81984 Noticed filamentous algae on lake-1984

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	900	39.2	39.2	39.2
Possibly Present	2.00	432	18.8	18.8	58.1
Definitely Present	3.00	961	41.9	41.9	100.0
	TOTAL	2293	100.0	100.0	

Valid Cases 2293 Missing Cases 0

Q81983 Noticed filamentous algae on lake-1983

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	87	3.8	6.7	6.7
Possibly Present	2.00	481	21.0	37.2	43.9
Definitely Present	3.00	726	31.7	56.1	100.0
	.	626	27.3	MISSING	
Dont Know	4.00	373	16.3	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 1294 Missing Cases 999

Q81982 Noticed filamentous algae on lake-1982

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	102	4.4	9.5	9.5
Possibly Present	2.00	473	20.6	43.9	53.3
Definitely Present	3.00	503	21.9	46.7	100.0
	.	742	32.4	MISSING	
Dont Know	4.00	473	20.6	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 1078 Missing Cases 1215

Q81981 Noticed filamentous algae on lake-1981

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	129	5.6	13.2	13.2
Possibly Present	2.00	439	19.1	44.9	58.1
Definitely Present	3.00	410	17.9	41.9	100.0
	.	791	34.5	MISSING	
Dont Know	4.00	524	22.9	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 978 Missing Cases 1315

Q81980 Noticed fil. algae on lake-1980 or earlier

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	179	7.8	17.5	17.5
Possibly Present	2.00	398	17.4	39.0	56.5
Definitely Present	3.00	444	19.4	43.5	100.0
	.	706	30.8	MISSING	
Dont Know	4.00	566	24.7	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 1021 Missing Cases 1272

Q9MAY Noticed filamentous algae in May, 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	247	10.8	36.4	36.4
Possibly Present	2.00	316	13.8	46.5	82.9
Definitely Present	3.00	116	5.1	17.1	100.0
	.	1050	45.8	MISSING	
Dont Know	4.00	564	24.6	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 679 Missing Cases 1614

Q9JUNE Noticed filamentous algae in June, 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	174	7.6	20.1	20.1
Possibly Present	2.00	408	17.8	47.1	67.2
Definitely Present	3.00	284	12.4	32.8	100.0
	.	990	43.2	MISSING	
Dont Know	4.00	437	19.1	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 866 Missing Cases 1427

Q9JULY Noticed filamentous algae in July, 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	1046	45.6	45.6	45.6
Possibly Present	2.00	411	17.9	17.9	63.5
Definitely Present	3.00	836	36.5	36.5	100.0
	TOTAL	2293	100.0	100.0	

Valid Cases 2293 Missing Cases 0

Q9AUG Noticed filamentous algae in Aug., 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	991	43.2	43.2	43.2
Possibly Present	2.00	361	15.7	15.7	59.0
Definitely Present	3.00	941	41.0	41.0	100.0
	TOTAL	2293	100.0	100.0	

Valid Cases 2293 Missing Cases 0

Q10 Rating of FA in past 5 yrs.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Very Noticeable	1.00	345	15.0	15.0	15.0
	2.00	369	16.1	16.1	31.1
	3.00	583	25.4	25.4	56.6
	4.00	444	19.4	19.4	75.9
Not Noticeable	5.00	552	24.1	24.1	100.0
	TOTAL	2293	100.0	100.0	

Valid Cases 2293 Missing Cases 0

Q11COL1 FA present in which part of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0.0	758	33.1	33.3	33.3
Few Parts of Lake	1.00	1081	47.1	47.5	80.9
Many Parts of Lake	2.00	361	15.7	15.9	96.7
All of Lake	3.00	74	3.2	3.3	100.0
	.	1	.0	MISSING	
Dont Know	4.00	18	.8	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2274 Missing Cases 19

Q11COL2 FA present in which part of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
None	0.0	713	31.1	31.2	31.2
Surface or Bottom	1.50	1088	47.4	47.7	78.9
Surface to Bottom	3.00	481	21.0	21.1	100.0
	.	1	.0	MISSING	
Dont Know	4.00	10	.4	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2282 Missing Cases 11

Q11COL3 FA present in which part of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	0.0	649	28.3	28.4	28.4
Only at the shore	1.50	1279	55.8	56.0	84.4
Away from Shore	2.00	2	.1	.1	84.5
Shore to Deep Water	3.00	354	15.4	15.5	100.0
Dont Know	4.00	9	.4	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2284 Missing Cases 9

Q12 Have you ever picked up filamentous algae

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Yes	1.00	1125	49.1	49.8	49.8
No	2.00	1136	49.5	50.2	100.0
	.	32	1.4	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2261 Missing Cases 32

Q13 How concerned are you about FA

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No Concern	1.00	285	12.4	12.4	12.4
	2.00	282	12.3	12.3	24.7
	3.00	668	29.1	29.1	53.9
	4.00	461	20.1	20.1	74.0
Extreme Concern	5.00	597	26.0	26.0	100.0
	TOTAL	2293	100.0	100.0	

Valid Cases 2293 Missing Cases 0

Q14A Fil. algae reduced enjoyment of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	966	42.1	44.1	44.1
A Little	2.00	754	32.9	34.4	78.5
A Fair Amount	3.00	313	13.7	14.3	92.8
A Great Deal	4.00	158	6.9	7.2	100.0
Uncertain	5.00	102	4.4	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 2191 Missing Cases 102

Q14B Fil. algae reduced fish pop. of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	340	14.8	35.8	35.8
A Little	2.00	206	9.0	21.7	57.5
A Fair Amount	3.00	213	9.3	22.4	79.9
A Great Deal	4.00	191	8.3	20.1	100.0
	.	371	16.2	MISSING	
Uncertain	5.00	972	42.4	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 950 Missing Cases 1343

Q14C Fil. algae reduced enjoyment of swimming

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	715	31.2	38.4	38.4
A Little	2.00	662	28.9	35.5	73.9
A Fair Amount	3.00	279	12.2	15.0	88.8
A Great Deal	4.00	208	9.1	11.2	100.0
	.	348	15.2	MISSING	
Uncertain	5.00	81	3.5	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 1864 Missing Cases 429

Q14D Fil. algae reduced enjoyment of boating

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	1366	59.6	74.9	74.9
A Little	2.00	336	14.7	18.4	93.4
A Fair Amount	3.00	81	3.5	4.4	97.8
A Great Deal	4.00	40	1.7	2.2	100.0
	.	369	16.1	MISSING	
Uncertain	5.00	101	4.4	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 1823 Missing Cases 470

Q14E Fil. algae affected your familys health

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	1197	52.2	89.1	89.1
A Little	2.00	92	4.0	6.9	96.0
A Fair Amount	3.00	26	1.1	1.9	97.9
A Great Deal	4.00	28	1.2	2.1	100.0
	.	366	16.0	MISSING	
Uncertain	5.00	584	25.5	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 1343 Missing Cases 950

Q14F Fil. algae reduced aesth. enjoy. of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	586	25.6	32.0	32.0
A Little	2.00	722	31.5	39.4	71.3
A Fair Amount	3.00	307	13.4	16.7	88.1
A Great Deal	4.00	219	9.6	11.9	100.0
	.	349	15.2	MISSING	
Uncertain	5.00	110	4.8	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 1834 Missing Cases 459

Q14G1 Fil algae has created other problems

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
A Little	2.00	1	.0	4.2	4.2
A Fair Amount	3.00	4	.2	16.7	20.8
A Great Deal	4.00	19	.8	79.2	100.0
	.	2268	98.9	MISSING	
Uncertain	5.00	1	.0	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 24 Missing Cases 2269

Q14G2 Specific other problems

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Adverse affects prop. value	1.00	4	.2	13.8	13.8
Affects quality of water	2.00	10	.4	34.5	48.3
Certain fish predomination	3.00	2	.1	6.9	55.2
Causes more insects	4.00	1	.0	3.4	58.6
Other	9.00	12	.5	41.4	100.0
	.	2264	98.7	MISSING	
	TOTAL	2293	100.0	100.0	

Valid Cases 29 Missing Cases 2264

Q15 Have you ever noticed odour algae on lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Definitely Yes	1.00	252	5.7	6.0	6.0
	2.00	164	3.7	3.9	10.0
Uncertain	3.00	504	11.4	12.1	22.1
	4.00	162	3.7	3.9	25.9
Definitely Not	5.00	3090	70.1	74.1	100.0
	.	235	5.3	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4172 Missing Cases 235

Q161985 Noticed odour algae on lake-1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	69	6.4	13.1	13.1
Possibly Present	2.00	212	19.6	40.3	53.4
Definitely Present	3.00	245	22.6	46.6	100.0
	.	365	33.7	MISSING	
Dont Know	4.00	191	17.7	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 526 Missing Cases 556

Q161984 Noticed odour algae on lake-1984

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	60	5.5	12.0	12.0
Possibly Present	2.00	198	18.3	39.7	51.7
Definitely Present	3.00	241	22.3	48.3	100.0
	.	400	37.0	MISSING	
Dont Know	4.00	183	16.9	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 499 Missing Cases 583

Q161983 Noticed odour algae on lake-1983

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	71	6.6	16.3	16.3
Possibly Present	2.00	167	15.4	38.4	54.7
Definitely Present	3.00	197	18.2	45.3	100.0
	.	437	40.4	MISSING	
Dont Know	4.00	210	19.4	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 435 Missing Cases 647

Q161982 Noticed odour algae on lake-1982

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	79	7.3	21.8	21.8
Possibly Present	2.00	152	14.0	41.9	63.6
Definitely Present	3.00	132	12.2	36.4	100.0
	.	488	45.1	MISSING	
Dont Know	4.00	231	21.3	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 363 Missing Cases 719

Q161981 Noticed odour algae on lake-1981

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	77	7.1	22.6	22.6
Possibly Present	2.00	158	14.6	46.3	68.9
Definitely Present	3.00	106	9.8	31.1	100.0
	.	504	46.6	MISSING	
Dont Know	4.00	237	21.9	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 341 Missing Cases 741

Q161980 Noticed OA on lake-1980 or earlier

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	83	7.7	23.0	23.0
Possibly Present	2.00	147	13.6	40.7	63.7
Definitely Present	3.00	131	12.1	36.3	100.0
	.	475	43.9	MISSING	
Dont Know	4.00	246	22.7	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 361 Missing Cases 721

Q17MAY Noticed odour algae in May, 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	115	10.6	39.1	39.1
Possibly Present	2.00	110	10.2	37.4	76.5
Definitely Present	3.00	69	6.4	23.5	100.0
	.	529	48.9	MISSING	
Dont Know	4.00	259	23.9	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 294 Missing Cases 788

Q17JUNE Noticed odour algae in June, 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	95	8.8	28.3	28.3
Possibly Present	2.00	146	13.5	43.5	71.7
Definitely Present	3.00	94	8.7	28.0	99.7
	5.00	1	.1	.3	100.0
	.	527	48.7	MISSING	
Dont Know	4.00	219	20.2	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 336 Missing Cases 746

Q17JULY Noticed odour algae in July, 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	70	6.5	14.5	14.5
Possibly Present	2.00	181	16.7	37.6	52.1
Definitely Present	3.00	231	21.3	47.9	100.0
	.	418	38.6	MISSING	
Dont Know	4.00	182	16.8	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 482 Missing Cases 600

Q17AUG Noticed odour algae in Aug., 1985

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not Present	1.00	76	7.0	15.9	15.9
Possibly Present	2.00	161	14.9	33.7	49.6
Definitely Present	3.00	240	22.2	50.2	99.8
	5.00	1	.1	.2	100.0
	.	418	38.6	MISSING	
Dont Know	4.00	186	17.2	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 478 Missing Cases 604

Q18 Rating of odour in past 5 years

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Strong Odour	1.00	60	5.5	8.0	8.0
	2.00	68	6.3	9.0	17.0
	3.00	154	14.2	20.5	37.5
	4.00	115	10.6	15.3	52.7
Mild Odour	5.00	356	32.9	47.3	100.0
	.	329	30.4	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 753 Missing Cases 329

Q19 Rating of concern about algae odour

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
No Concern	1.00	193	17.8	17.8	17.8
	2.00	152	14.0	14.0	31.9
	3.00	464	42.9	42.9	74.8
	4.00	128	11.8	11.8	86.6
Extreme Concern	5.00	145	13.4	13.4	100.0
	TOTAL	1082	100.0	100.0	

Valid Cases 1082 Missing Cases 0

Q20A Algae odour reduced enjoyment of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	535	49.4	53.3	53.3
A Little	2.00	282	26.1	28.1	81.4
A Fair Amount	3.00	120	11.1	12.0	93.3
A Great Deal	4.00	67	6.2	6.7	100.0
Uncertain	5.00	78	7.2	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 1004 Missing Cases 78

Q20B Algae odour reduced fish pop. of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	412	38.1	65.8	65.8
A Little	2.00	80	7.4	12.8	78.6
A Fair Amount	3.00	72	6.7	11.5	90.1
A Great Deal	4.00	62	5.7	9.9	100.0
	.	62	5.7	MISSING	
Uncertain	5.00	394	36.4	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 626 Missing Cases 456

Q20C Algae odour reduced enjoy. of swimming

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	519	48.0	54.9	54.9
A Little	2.00	220	20.3	23.3	78.1
A Fair Amount	3.00	127	11.7	13.4	91.5
A Great Deal	4.00	80	7.4	8.5	100.0
	.	62	5.7	MISSING	
Uncertain	5.00	74	6.8	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 946 Missing Cases 136

Q20D Algae odour reduced enjoyment of boating

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	731	67.6	77.8	77.8
A Little	2.00	135	12.5	14.4	92.1
A Fair Amount	3.00	54	5.0	5.7	97.9
A Great Deal	4.00	20	1.8	2.1	100.0
	.	62	5.7	MISSING	
Uncertain	5.00	80	7.4	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 940 Missing Cases 142

Q20E Algae odour affected familys health

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	649	60.0	88.4	88.4
A Little	2.00	44	4.1	6.0	94.4
A Fair Amount	3.00	22	2.0	3.0	97.4
A Great Deal	4.00	19	1.8	2.6	100.0
	.	62	5.7	MISSING	
Uncertain	5.00	286	26.4	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 734 Missing Cases 348

Q20F AO reduced aesth. enjoyment of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not at All	1.00	544	50.3	58.8	58.8
A Little	2.00	221	20.4	23.9	82.7
A Fair Amount	3.00	94	8.7	10.2	92.9
A Great Deal	4.00	66	6.1	7.1	100.0
	.	62	5.7	MISSING	
Uncertain	5.00	95	8.8	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 925 Missing Cases 157

Q20G1 Algae odour has created other problems

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
A Little	2.00	3	.3	21.4	21.4
A Fair Amount	3.00	4	.4	28.6	50.0
A Great Deal	4.00	7	.6	50.0	100.0
	.	1066	98.5	MISSING	
Uncertain	5.00	2	.2	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 14 Missing Cases 1068

Q20G2 Specific other problem

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Adverse prop. value	1.00	3	.3	17.6	17.6
Affects quality of water	2.00	12	1.1	70.6	88.2
	.	1065	98.4	MISSING	
	TOTAL	1082	100.0	100.0	

Valid Cases 17 Missing Cases 1065

Q21A Noticed slippery film on rocks in past 5 years

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	1510	34.3	34.3	34.3
Notice Occasionally	2.00	1253	28.4	28.4	62.7
Noticed Many Times	3.00	846	19.2	19.2	81.9
Notice Always	4.00	798	18.1	18.1	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q21B Noticed odour-strong tasting water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	3416	77.5	77.5	77.5
Notice Occasionally	2.00	640	14.5	14.5	92.0
Noticed Many Times	3.00	213	4.8	4.8	96.9
Notice Always	4.00	138	3.1	3.1	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q21C Noticed brown coloured water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	2785	63.2	63.2	63.2
Notice Occasionally	2.00	706	16.0	16.0	79.2
Noticed Many Times	3.00	336	7.6	7.6	86.8
Notice Always	4.00	580	13.2	13.2	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q21D Noticed green scum on water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	3212	72.9	72.9	72.9
Notice Occasionally	2.00	943	21.4	21.4	94.3
Noticed Many Times	3.00	208	4.7	4.7	99.0
Notice Always	4.00	43	1.0	1.0	100.0
	.	1	.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4406 Missing Cases 1

Q21E Noticed yellow scum on water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	3576	81.1	81.2	81.2
Notice Occasionally	2.00	670	15.2	15.2	96.4
Noticed Many Times	3.00	134	3.0	3.0	99.4
Notice Always	4.00	26	.6	.6	100.0
	.	1	.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4406 Missing Cases 1

Q21F Noticed clouds of algae in water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	2828	64.2	64.2	64.2
Notice Occasionally	2.00	963	21.9	21.9	86.0
Noticed Many Times	3.00	505	11.5	11.5	97.5
Notice Always	4.00	111	2.5	2.5	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q21G Noticed green slime on rocks

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	1775	40.3	40.3	40.3
Notice Occasionally	2.00	1340	30.4	30.4	70.7
Noticed Many Times	3.00	766	17.4	17.4	88.1
Notice Always	4.00	526	11.9	11.9	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q21H Noticed vegetation in water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	936	21.2	21.2	21.2
Notice Occasionally	2.00	1106	25.1	25.1	46.3
Noticed Many Times	3.00	959	21.8	21.8	68.1
Notice Always	4.00	1406	31.9	31.9	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q21I Noticed frothy white foam

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	1114	25.3	25.3	25.3
Notice Occasionally	2.00	2105	47.8	47.8	73.0
Noticed Many Times	3.00	929	21.1	21.1	94.1
Notice Always	4.00	259	5.9	5.9	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q21J Noticed many dead fish

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	3859	87.6	87.6	87.6
Notice Occasionally	2.00	519	11.8	11.8	99.3
Noticed Many Times	3.00	28	.6	.6	100.0
Notice Always	4.00	1	.0	.0	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q22A Frequency cooking cabbage odour present

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	4169	94.6	94.6	94.6
Notice Occasionally	2.00	183	4.2	4.2	98.8
Noticed Many Times	3.00	39	.9	.9	99.6
Notice Always	4.00	16	.4	.4	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q22B Frequency grassy musty odour present

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	3428	77.8	77.8	77.8
Notice Occasionally	2.00	772	17.5	17.5	95.3
Noticed Many Times	3.00	161	3.7	3.7	99.0
Notice Always	4.00	46	1.0	1.0	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q22C Frequency fishy odour present

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	2719	61.7	61.7	61.7
Notice Occasionally	2.00	1345	30.5	30.5	92.2
Noticed Many Times	3.00	297	6.7	6.7	99.0
Notice Always	4.00	46	1.0	1.0	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q22D Frequency septic sewage odour present

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	4081	92.6	92.6	92.6
Notice Occasionally	2.00	266	6.0	6.0	98.6
Noticed Many Times	3.00	50	1.1	1.1	99.8
Notice Always	4.00	10	.2	.2	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q22E Frequency rotten garbage odour present

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	4250	96.4	96.4	96.4
Notice Occasionally	2.00	122	2.8	2.8	99.2
Noticed Many Times	3.00	28	.6	.6	99.8
Notice Always	4.00	7	.2	.2	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q22F Frequency dead-decaying odour present

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	3900	88.5	88.5	88.5
Notice Occasionally	2.00	418	9.5	9.5	98.0
Noticed Many Times	3.00	74	1.7	1.7	99.7
Notice Always	4.00	15	.3	.3	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q22G1 Frequency other odour present

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never Noticed	1.00	12	.3	9.0	9.0
Notice Occasionally	2.00	48	1.1	36.1	45.1
Noticed Many Times	3.00	48	1.1	36.1	81.2
Notice Always	4.00	25	.6	18.8	100.0
	.	4274	97.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 133 Missing Cases 4274

Q23A Biggest problem: too much recr. activity

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	2961	67.2	67.2	67.2
IS A PROBLEM	2.00	1444	32.8	32.8	100.0
	.	2	.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4405 Missing Cases 2

Q23B Biggest problem: too much shoreline dev.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	2954	67.0	70.0	70.0
IS A PROBLEM	2.00	1267	28.7	30.0	100.0
	.	186	4.2	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4221 Missing Cases 186

Q23C Biggest problem: poor aesthetics of lake

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	3251	73.8	77.0	77.0
IS A PROBLEM	2.00	970	22.0	23.0	100.0
	.	186	4.2	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4221 Missing Cases 186

Q23D Biggest problem: acid rain affect

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	1748	39.7	39.7	39.7
IS A PROBLEM	2.00	2659	60.3	60.3	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q23E Biggest problem: filamentous algae

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	3122	70.8	70.9	70.9
IS A PROBLEM	2.00	1283	29.1	29.1	100.0
	.	2	.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4405 Missing Cases 2

Q23F Biggest problem: poor lake water quality

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	2237	50.8	50.8	50.8
IS A PROBLEM	2.00	2168	49.2	49.2	100.0
	.	2	.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4405 Missing Cases 2

Q23G Biggest problem: dead-decl. fish pop.

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	2822	64.0	64.0	64.0
IS A PROBLEM	2.00	1585	36.0	36.0	100.0
	TOTAL	4407	100.0	100.0	

Valid Cases 4407 Missing Cases 0

Q23H Biggest problem: algae odour

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NOT A PROBLEM	1.00	3854	87.5	87.5	87.5
IS A PROBLEM	2.00	551	12.5	12.5	100.0
	.	2	.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4405 Missing Cases 2

Q24A Frequency of swimming or wading

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never or rarely	1.00	101	2.3	2.3	2.3
Occasionally	2.00	721	16.4	16.5	18.9
Frequently	3.00	3538	80.3	81.1	100.0
	.	47	1.1	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4360 Missing Cases 47

Q24B Freqency of sitting by water

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never or rarely	1.00	35	.8	.8	.8
Occasionally	2.00	414	9.4	9.5	10.3
Frequently	3.00	3907	88.7	89.7	100.0
	.	51	1.2	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4356 Missing Cases 51

Q24C Frequency of motorboating-waterskiing

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never or rarely	1.00	970	22.0	23.8	23.8
Occasionally	2.00	1040	23.6	25.5	49.3
Frequently	3.00	2069	46.9	50.7	100.0
	.	328	7.4	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4079 Missing Cases 328

Q24D Frequency of canoeing/rowing/sailing

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never or rarely	1.00	506	11.5	11.8	11.8
Occasionally	2.00	1196	27.1	28.0	39.8
Frequently	3.00	2572	58.4	60.2	100.0
	.	133	3.0	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4274 Missing Cases 133

Q24E Frequency of fishing activity

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Never or rarely	1.00	933	21.2	21.5	21.5
Occasionally	2.00	1715	38.9	39.6	61.1
Frequently	3.00	1686	38.3	38.9	100.0
	.	73	1.7	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4334 Missing Cases 73

Q25 Rating familiarity with lake conditions

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Not At All Familiar	1.00	361	8.2	8.3	8.3
	2.00	589	13.4	13.5	21.8
	3.00	1202	27.3	27.6	49.5
	4.00	957	21.7	22.0	71.5
Very Familiar	5.00	1242	28.2	28.5	100.0
	.	56	1.3	MISSING	
	TOTAL	4407	100.0	100.0	

Valid Cases 4351 Missing Cases 56